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MEMOIRS

OF THE

CONNECTICUT ACADEMY

OF

Arts and Sciences.

VOL. I.—PART I.

NEW-HAVEN,
PRINTED BY OLIVER STEELE AND CO.

1810.

PREFACE.

THE design of forming a Society, which might combine the efforts of literary men in Connecticut, for the promotion of useful knowledge, was suggested early in the year 1799. A few gentlemen in New-Haven attended a meeting at an invitation given; and a sketch of the principal objects of such an Association was communicated, together with the outline of the proposed Society, which was named "The Connecticut Academy of Arts and Sciences."

At a meeting on the fourth of March, the Gentlemen, who had associated, adopted a number of regulations, as bye-laws for their government; and elected a number of gentlemen in various parts of the State to be Members. At a subsequent meeting, certain fundamental articles were adopted as the Constitution of the Academy, by which were prescribed the terms of admission to membership. In October following, the Academy, on petition, obtained from the Legislature the Act of Incorporation, which is subjoined.

The Academy meets annually on the fourth Tuesday of October, for the choice of its Officers, and holds stated meetings on the fourth Tuesday of December, February, April, June, and August. The Officers are a President, Vice-Presidents, five Counsellors, a Secretary, Treasurer, Keeper of the Cabinet, a Committee of Publication, and Corresponding Secretaries.

One considerable object proposed by this Association, was to collect for publication a Statistical Account of the State of Connecticut; and to the accomplishment of this object they have directed their attention and exertions. On the first of January 1800, they addressed a circular letter to every town in the State, containing the subjects of inquiry arranged under thirty-two distinct heads, and requesting answers to their inquiries. This letter was printed and distributed. In a subsequent address, the Academy urged an attention to the subject of those inquiries, and suggested a plan, by which they supposed the labor of furnishing correct answers might be greatly facilitated. This business is still in progress ; and nearly thirty papers containing answers to the above-mentioned letter, have been received.

But this object is necessarily temporary and local. The main design of the Institution is more widely extended. At its commencement, a scheme was drawn up, reported, and approved, in which the attention of its members was invited to every method of improving the science, arts, and happiness of their country, so far as the general state of its concerns, and their own leisure, would permit. Knowledge, both speculative and practical, was here, in all its parts, recommended to their attention, as the great field, in which they are requested to labor for the common benefit. No limit is prescribed to the excursions of the mind, or to the employment of observation. The elegant pursuits of literature and art, are left equally open to investigation with those, which are more severe. In a word, it was intended to allure the ingenious, attentive, and learned, to every public effort, which might be beneficial to their fellow men. In compliance with this design, several papers on philosophical subjects have been presented to the Academy. Among them the following have been selected for publication. They constitute only part of an intended volume ; and are sent out in boards, that they may be conveniently preserved without injury, until the volume shall be completed.

AN ACT

To incorporate the Connecticut Academy of Arts and Sciences.

WHEREAS literary Societies have been found to promote, diffuse and preserve the knowledge of those Arts and Sciences, which are the support of Agriculture, Manufactures and Commerce, and to advance the dignity, virtue and happiness of a people: Therefore,

Be it enacted by the Governor and Council, and House of Representatives, in General Court assembled, That Timothy Dwight, James Dana, Zephaniah Swift, John Allen, David Daggett, Jesse Root, John C. Smith, Isaac Beers, Nathaniel Smith, Elijah Munson, Josiah Meigs, Enoch Perkins, Jeremiah Atwater, 4th. John Barker, Elias Shipman, Noah Webster, jun. Simeon Baldwin, Elizur Goodrich, Obadiah Hotchkiss, jun. Timothy Pitkin, jun. Theodore Dwight, Abraham Bishop, Ashur Miller, Stephen Titus Hosmer, James Hillhouse, Jeremiah Wadsworth, Pierpont Edwards, Isaac Mills, Eli Whitney, John Davenport, John Bowden, Bela Hubbard, Jonathan O. Moseley, Jonathan Sturgiss, Elizur Wright, Jeremiah Townsend, jun. Jared Mansfield, John Marsh, Nathan Perkins, Levi Hart, John Treadwell, Oliver Ellsworth, Jonathan Trumbull, and Eneas Munson, and their associates, be, and they hereby are formed into, constituted and made a body politic and corporate, by the name of "*The Connecticut Academy of Arts and Sciences,*" and by that name, they and their successors shall and may have perpetual succession; shall be capable of suing and being sued, pleading and being impleaded, in all suits, of what nature soever; may have a Common Seal, and may alter the same at pleasure; and may also purchase, receive, hold and convey any estate, real or personal; provided that the annual income of such estate shall not exceed one thousand dollars.

2d. *And be it further enacted,* That the said Academy may, from time to time, elect a President and a Keeper of Records, which Keeper of Records shall be sworn to a faithful discharge of his trust; and such other officers as they may find necessary or convenient; may elect additional members, provided the whole number of members resident in this state shall never exceed two hundred, nor ever be less than forty. And the said Academy may make bye-laws respecting the number, qualifications and duties of their Officers; the mode of election and admission of members; the time, place and manner of holding their meetings; and the number necessary to make a quorum, and all other bye-laws which they may deem necessary for the due regulation of said Society, not repugnant to the laws of the state or of the United States; and may annex reasonable pecuniary fines and penalties, for the breach of such bye-laws, not exceeding ten dollars for one offence.

3d. *And be it further enacted*, That the first meeting of said Academy be held at the State House in New-Haven, on the fourth Tuesday of instant October.

4th. *And be it further enacted*, That this Act or any part thereof, if found inadequate or inconvenient, may be altered, amended, or repealed.

A LIST

OF THE

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His Excellency John Treadwell, Esq.
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Mr. William W. Woolsey,
Jonathan Walter Edwards, Esq.

Those with an asterisk prefixed are deceased.

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No. I.

A DISSERTATION

On the supposed Change in the Temperature of Winter:

READ BEFORE THE CONNECTICUT ACADEMY OF ARTS AND SCIENCES....1799.

BY N. WEBSTER, JUN. ESQ.

IT is a popular opinion that the temperature of the winter season, in northern latitudes, has suffered a material change, and become warmer in modern, than it was in ancient times. This opinion has been adopted and maintained by many writers of reputation; as the Abbè du Bos, Buffon, Hume, Gibbon, Jefferson, Holyoke, Williams; indeed I know not whether any person, in this age, has ever questioned the fact.*

The arguments to prove that the winters, in ancient times, were far colder than at present, are the following. First, in regard to Palestine or Judea.

It is said that several passages in the scriptures, written as early as the days of Moses and David, speak of snow, hail, ice, and hoar frost, as common in those ages, where no such thing is now known. " He giveth snow

* Hume's Essays, vol. i. 457. Ess. xi.—Gibbon's Hist. vol. i. ch. ix.—Williams's Hist. of Vermont, p. 63. first ed. and appendix, No. 2.—Jefferson's Notes, query 7.—Memoirs of Amer. Acad. vol. ii. part 1. 70.—Pelloutier's Hist. des Celtes, liv. xii.—Cyclopedia by Rees: Art. CLIMATE.

like wool; he scattereth the hoar frost like ashes. He casteth forth his ice like morsels; who can stand before his cold? The face of the deep was frozen," &c.

The passages in Job which mention snow, hail, ice and frost, are numerous. Dr. Williams supposes, with many others, that the book of Job was written by Moses; and that the descriptions refer to the land of Midian or Palestine, about the latitude of 30 or 31° north. He supposes also, that to produce solid ice on rivers, to answer to the descriptions, a degree of cold is necessary, corresponding with 25° by Farenheit. This he concludes to have been the extremity of cold, in the land of Midian, in the age of Moses.

The writings of David mention ice in the form of "morsels," or crystals, which Dr. Williams has observed to be congealed in a temperature of about 31° by Farenheit. On the strength of this single circumstance, he concludes that the climate, in about 400 years, between Moses and David, had become warmer by six degrees.

I am really surprised to observe on what a slight foundation, a divine and philosopher has erected this theory. In the first place, we have no evidence that Moses wrote the book of Job; on the contrary, there is strong evidence that he was not the author.

Critics are not all agreed whether that book describes a series of facts, or is a species of dramatic composition, intended to represent the vicissitudes of life, and the human passions. Respectable and pious men are found on both sides of this question.

But it is not very material as to the present argument. It is sufficient for my purpose, that the *scene* of that book is expressly laid in the land of Uz, near Chaldea, which is in that part of Arabia, called the Desert, extending from Syria and Judea, to Chaldea on the east, and the Euphrates on the north.* Now, we have strong evidence that Moses was never in that country. He was born in Egypt; he afterwards fled to Midian, then returned to Egypt to deliver his countrymen from their

* Sir William Jones has remarked, that the book of Job, from the language, must have been written by a man of Arabian extract.—*Asiatic Researches.* Bochart, from Hieronymus, observes that Job must have been well versed in Arabic.—*Geog. Sac.* cap. xv.

bondage; but was not permitted to go farther north than mount Nebo, in the land of Moab, over against Jericho, just upon the borders of Judea, and this but a short time before his death.

It is very evident that Moses had never before seen that country, because he was directed to ascend the mount, and take a view of the lands destined to be the residence of the Israelites—a circumstance that plainly indicates his former ignorance of the country, which could not have been the case, had he ever dwelt in Uz, to the north and east of Judea; for in that case he must have passed through this country.

Nor is it at all probable that the writer of that book would lay the scene of it in a country of which he was ignorant. Every circumstance tends to prove that the writer knew the country, its climate and productions; and the frequent mention of snow, ice and frost in Job is the highest evidence that the author had lived in a region where these substances were common and well known. If we suppose the writer to have lived in Judea, or in the northern parts of Arabia Deserta, the situation of Uz, he must have seen snow and ice every winter; but Moses probably had little or no knowledge of them. In Midian and Egypt, where he had spent his days, they rarely occurred; and in the five books, supposed to be of his writing, there are scarcely two or three references to snow or frost. In the 31st chapter of Genesis, Jacob is represented as complaining to Laban that he had served him twenty years, enduring drouth by day and frost by night; but this was in Padan-haran, to the northward of Jerusalem. In Exodus xvi. 14, the manna in the wilderness is compared to hoar-frost; and in the 6th chapter, a leprous hand is compared to snow. But in all the acknowledged writings of Moses, there is not the least evidence that ice was ever seen in Egypt, except in the time of the ten plagues, and in the form of hail. The silence of those early records, on this point, is no small argument, that the climate of Egypt was then as warm as it is at this day. Hail has been sometimes seen in that country, as it is in many other parts of the world where there is no weather cold enough to congeal water on the earth.*

Instead therefore of proving that snow and ice were formerly common in Midian and Palestine, the frequent mention of these substances in Job, is almost conclusive evidence that Moses was not the author. That book, which is an excellent description of human nature, was unquestionably written by some person, either in Uz, or the northern parts of Judea, where ice, frost and snow were then, and are now, annually seen on the mountains. "If I wash myself in snow water, and make my hands never so clean," says Job, chapter 9th; which is a description that would not answer for Egypt or Midian,† but answers well to the greatest part of Judea. "The sweet influences of Pleiades," mentioned in the 38th chapter, allude doubtless to the spring rains, which fell in Judea about the rising of that constellation, which, in Pliny's time, happened near the vernal equinox, but which, fifteen hundred years earlier, must, by the precession of the equinox, have happened about the first of March. This circumstance answers well to the climate of Syria, but not at all to that of Egypt, where the rising of that constellation was the most sickly and disagreeable time in the year. The former and latter rain, mentioned also in that book, indicate that it was descriptive of the climate of Syria and Judea; for the success of agriculture did then, as it does now, depend entirely on the autumnal and spring rains. This division of rainy seasons however did not exist in Egypt; it was used only in Syria and Italy, and perhaps in Greece. Every circumstance that occurs to my view, in regard to the book of Job, tends to prove that Moses could not have been the author; and most of the Jewish Rabbins have been of this opinion. Certain it is, from internal evidence, that the scene of it was laid in a country much colder than Midian, or the champaign country of Pales-

*See an account of a hail-storm in Africa—Hirtius Pansa de Bello Afric. 42.

† I speak of the Midian, near the Arabic Gulf, where Moses lived, with his father in law; not of Midian on the borders of Judea.

tine; for Herodotus, in Eterpe, expressly declares that no ice was seen in Egypt; and, in another passage, that the climate is subject to no variations.

Let us then attend to the process by which Dr. Williams attempts to prove a change of climate in Palestine. He *presumes* Moses wrote the book of Job—that the descriptions of ice and snow refer to the land of Midian and Palestine, and therefore that the winter, in those early ages, must have been severe enough to freeze solid ice, which, he says, requires a temperature of about 25° by Farenheit. He has no meteorological observations for Palestine, but presumes the climate to be nearly the same, as to heat, with that of Egypt. Mr. Niebuhr's observations in Grand Cairo in 1761 and 2, make the mean heat of January 57, and of February 63—the coldest weather therefore he supposes to be about 49° by Farenheit. Hence, if Palestine and Egypt have nearly a similar climate, he draws the conclusion that, in modern days, "no ice or snow is ever seen in Palestine."

This inference is drawn from a very inaccurate view of the subject. The facts with regard to Palestine at this day, are these.

The whole country comprehended between Aleppo on the north, the Mediterranean on the west, and the barren plains of Arabia on the south and east, is divided into high hills, mountains and plains. Palestine on the south, is a level plain, and a very warm country. The thermometer in winter is seldom seen below 50°. If snow ever falls, it is speedily dissolved. In this mild climate, which extends along the Mediterranean shore, the orange, date, banana, and other delicate trees flourish, without injury from the winter's cold. Little fire is necessary for the inhabitants; instead of fire, which is sometimes wanted during the cool rains of winter, the poor people shut up their cattle under the same roof with themselves, in a different apartment, and receive heat enough from their bodies to make themselves comfortable. Such is the present climate of the plains.

But a great part of Syria and Judea consists of mountains, which are every winter covered with snow; and often the earth is covered, for months, to the depth of several feet. The mountains from Aleppo to Jerusalem, are covered with snow every winter; and when the snow melts, the Jordan overflows its banks. This happens in March; but on some of the highest hills, as mount Lebanon and Akkar, the snow is seen, till the middle of summer. This was the fact in 1784, when Volney visited that country. See his Travels, from which these facts are extracted. This author further observes, that on the east of the mountains, the cold is more rigorous than on the sea coast; and at Aleppo, Antioch and Damascus, are several weeks of frost and snow every winter. The inhabitants of the mountains leave their habitations, which are buried in snow, in winter, and pass the season at Tripoli, on the sea coast.*

The principal part of Judea, or the Holy Land, lies on the east side of the mountains, and experiences snow, frost and ice every winter. What shall we say then to the assertion of Dr. Williams, that in Palestine, "snow and ice are never seen" in modern days.

In Syria and Palestine, wheat and barley are sown in autumn, about the last week in October; the time of the autumnal rains. Harvest, in the plains, is in April and May. On the mountains, it is in June and July. Spring crops are planted in March and April.†

Common winters therefore in Judea are mild in the plains, but cold on the hills. That country however is subject, like others, to severe winters, which prove destructive to men and vegetables. The poverty of the great body of the people, and the mildness of ordinary

* "Will a man leave the *snow of Lebanon*"....Jer. xviii. 14. Shaw, in his Travels, p. 362, says, mount Libanus, in winter, is covered with snow—and p. 363, that snow at Jerusalem in February, causes great rejoicings. He mentions that snow fell at Cairo, Jan. 10, 1639.

† If the *byssus* of the ancient Egyptians was really cotton, as the commentators on Herodotus assert, then cotton must have been the produce of Egypt, from the earliest times, as the bandages in which mummies were wrapped, consisted of that article....*Beloe. Herod. Euterpe.* 86. *Note.*

When Ezra returned from the captivity, and set about reforming the abuses of marriage among the Jews, he assembled the men of Judah and Benjamin, on the 20th day of the 9th month, and it was a time of great *rain*. This was about the 10th or 12th of Dec....*Ez*.x.9.

winters, prevent the same preparations to defend against cold, which are made in more northern latitudes. In 1741—2, the winter in Syria was very severe; and that of 1756—7 sunk the mercury into the bulb, at Aleppo; multitudes of vines were killed, as were olives that had stood fifty years. Many of the poorer people perished with cold. In winters like that, I presume, ice is formed in the mildest regions of Palestine....*See Lond. Mag.* 1764.

That ordinary winters were far less severe, is obviously inferable from Exod. xxxv. 3. "Ye shall kindle no fire throughout your habitations upon the Sabbath Day"—an injunction which had reference to all seasons of the year; and which could not have been given in a climate where fire was indispensable to the health and comfort of the inhabitants.

But the most positive evidence which can possibly exist to prove that the climate of Palestine has *not* suffered any increase of heat, for more than 3000 years, is the production of certain fruits in the days of David, which will not thrive in any but mild, warm countries; as pomgranates, olives and figs. The trees producing these fruits are so often mentioned in Scripture, that it would be idle to name the instances. They were in Judea in the time of Moses in the greatest abundance; for the spies sent to explore the country, returned with pomgranates and figs....*Numb.* xiii. 23.

We know precisely the degree of heat necessary to bring these fruits to perfection: That is, a climate as mild as South-Carolina and Georgia. Figs and olives grow well in Virginia, says Mr. Jefferson, but are liable to be killed by frost. We then ascertain beyond all controversy, that Palestine, in the days of Moses, was as warm a country as South Carolina and Georgia are in this age.

The palm-tree furnishes, also, a most clear and incontestible proof of the same fact. This tree will grow and bear fruit, says Pliny, in the maritime parts of Spain, but the dates have not the fine flavor of those which are produced in Judea. In Europe, for instance in Italy, they are barren. In Africa they come to perfection, but soon perish. "Judea vero inclyta est vel magis palmis," says that author. "Judea is particularly renowned for palm-trees or dates."....*Lib.* xiii. *Ca.* 4.

These trees were not introduced and cultivated first in Judea by the Jews. The Israelites, when they migrated from Egypt, found palm-trees in the neighborhood of Jericho, and in the plains of Moab, in all their glory. Jericho is called the city of palm-trees—Deut. xxxiv 3. and the word itself, in the Ethiopic, signifies a palm-tree....*Ludolf's Lexicon, col.* 37.

No man will be sceptical enough to deny a uniformity in the laws of the vegetable economy. We have then *certain proof* that Palestine, more than 3000 years ago, was a milder climate than Italy, milder than the south of France, as mild as the coast of Africa, at that time, and milder than South Carolina at this day.

Another remarkable fact is decisive of this question. The Jewish month האביב *Abib*, was named from the ripeness of barley in Palestine and Egypt, at that season; the word signifying fullness or ripeness from the *swelling* form of the grain. *Abib* answers to the latter part of March and the beginning of April, which was the time of harvest in the earliest ages. Now this is the precise time of harvest in modern days.*

The facts above enumerated solve all questions as to the ancient climate of Judea and Egypt. Frost, snow, and ice were annually seen on the hills and mountains of Palestine, and were perfectly well known to writers among the Jews; hence the justness of the descriptions in Job and other parts of the Old Testament. In hard winters, these phenomena must have been extended over the plains, along the banks of Jordan; and perhaps on the sea coast. But the plains in common years must have been very mild and warm. All this is precisely the state of the climate in Palestine, in the present age.

Confirmatory and decisive of this inference is the fact, that from the earliest records of history, the inhabitants of Judea constructed their houses with flat roofs, as they do at this day, on which they not only amused themselves

* See Shaw's Travels, p. 364, folio, and p. 430.—Niebuhr's Trav. Sect. xxviii. ch. 3.—Park. Lex. under אב.

during the day, but erected altars, offered incense, and performed other pagan rites to the deities of the country; and we have the express authority of the Scriptures to prove that as early as the days of Samuel, it was customary to sleep on the tops of the houses, as it is at this day. *See Deut.* xxii. 8—*Josh.* ii. 6—*Judges* xvi. 27—*Jer.* xix. 13—*Zeph.* i. 5—*Dan.* iv. 29—1 *Sam.* ix. 25, 26.

In winter, it was not unusual to kindle fires in Judea. Thus we find Jehoiakim sat by a fire in the *ninth* month, Chisleu, which answers to a part of our November and December....Jer. xxxvi. 22—and Dr. Russel informs us that at Aleppo, they begin to kindle fires about the end of November....*Nat. Hist. of Aleppo, p.* 14. *Parkhurst,* 330, under כסל.

Dr. Williams proceeds to prove that the winters in Italy have, in about eighteen centuries, become warmer by seventeen degrees on Farenheit's scale. His proofs are, that Virgil in many places of his Georgics, has given directions for securing cattle and sheep from the effects of snow and cold—that Virgil, Pliny, Juvenal and Ælian speak of ice, snow, and the freezing of rivers, as events common and annual. But he observes, that in 1782 and 3, the mean temperature at Rome in January was 46°, and the mean of the greatest cold 42°, which is 17 degrees less cold than what is necessary for the freezing of rivers.

The Abbè du Bos, Hume, and others alledge, in proof of the same doctrine, the following facts: In the year of Rome 480, the winter was so severe as to kill the trees—the Tiber was frozen, and the ground was covered with snow for forty days. Juvenal describes a superstitious woman as breaking the ice of the Tiber to perform her ablutions.

> "Hybernam fracta glacie descendet in amnem,
> Ter matutino Tiberi mergetur."....*Sat.* vi. 521.

Horace also, says the Abbè, speaks of the streets of Rome as full of ice and snow. These authors, it is alledged, speak of these as common events. But, says the Abbè, "at present the Tiber no more freezes at Rome, than the Nile at Cairo."*

* I cite this from Hume. Ess. xi.

Dr. Holyoke mentions the description of the severe winter A. U. C. 536, in the second Punic war, when the siege of a town in Spain, near the present Barcelona, was obstructed by snow which lay for thirty days to the depth of four feet....*See Memoirs of Am. Academy, vol.* ii. 70.

From these representations, it is concluded that Italy has now a much more temperate climate than at and before the Christian era. Let us examine this point.

Dr. Holyoke gives us the mean of the greatest cold at Rome, deduced from several years' observations, within the last half century; which is 33° 46, a little above freezing point. The greatest cold is stated at 31°. If we admit this statement to be correct, then Dr. Williams has stated the extreme of cold in Rome almost nine degrees too high; of course we must deduct *nine* degrees from his seventeen degrees of alteration, in eighteen centuries, which is a very material difference.

This we must do, and more. For Brydone in the winter of 1769—70, found the greatest cold at Rome in January to be 27°, a degree capable of covering large rivers with a thin coat of ice. That winter was perhaps colder than usual; but by no means of the severest kind.—At Naples, says Brydone, we had rainy weather; at Rome, it was clear and *frosty*. That winter then would at Rome produce all the phenomena of ice, frost, and snow, to answer the description of the Latin writers of the Augustan age.

If the mean temperature of the winter's cold at Rome is now about 33°, it is not more than eight degrees milder weather than in New England; for Dr. Holyoke found, by seven years' observations, that the mean winter temperature at Salem, in Massachusetts, is 25° 74.

I know not the position of the thermometer by which the observations at Rome were made. But I would remark that, if those observations were made in the city, they do not represent the general temperature of Italy. I found by numerous observations in New-York, that ice as thick as glass in our windows, was uniformly made at a mile's distance from the city, when an accurate thermometer in the coldest positions *in* the city stood at 40°. Such is the difference between the real temperature of an open country, and the artificial one of a city. The same difference will not run through the observations of the whole year, but it will amount to two or three degrees. I am inclined to believe this to be the source of great errors, in comparing meteorological observations in different countries.

If the ordinary winter temperature at Rome is near the freezing point, we are at no loss to account for the snow and ice of Italy in ancient times. In all countries, and in every latitude, hills and mountains are cooler than plains. This difference is according to the difference of altitude; but between Rome, in a plain, near the sea, and the Appenines, it cannot be less than from six to ten degrees. Thus while at Rome and in Campania generally, the weather is mild, and exhibits little or no ice, the whole ridge of mountains between Tuscany and Naples, that region of Italy which furnished the pasturage, and for which the directions in Virgil's Georgics were intended, is covered with snow, and experiences severe frosts. This was not only the fact in Virgil's time, but is so at this day. Mr. Arthur Young, a distinguished agriculturist, travelled in Italy in November and December 1789. In passing the Appenines, between Florence and Bologna, the first days of December, he found the hills almost covered with snow; and the roads, on some declivities, a sheet of ice. On the 26th of November, the weather was so severe as to freeze Cyprus wine, and milk burst the vessels that contained it. In Lombardy, he found the peasantry at night, sitting in a passage between their cattle, in the stables, to keep themselves warm; a practice resembling that in Palestine, already mentioned.*

It is well known also that the higher regions of mount Etna in Sicily, a far milder climate than that of Italy, are perpetually covered with snow.

That the descriptions of ice and snow, in the Augustan age, allude principally to the hilly country, is very obvious from the writings of Virgil, Horace, and Pliny.

* Young's Tour, Vol. i. p. 516. Dub. 1793.

Virgil, in his first Georgic, speaks of the Zephyrs dissolving the earth, and bringing moisture from the *whitened hills.*

Horace, in his ninth Ode, mentions deep snow on mount Soracte, in Etruria, about twenty-six miles north of Rome.

Pliny, in the nineteenth book of his Natural History, is more explicit on this subject. Speaking of the luxury of his days, he says, "Hi nives, illi glaciem potant; pœnasque montium in voluptatem gulæ vertunt."…. "Some drink snow, others ice; and the evil or scourge of the mountains is converted into a gratification of the palate." This passage leaves no room to question, that the ice and snow used in Rome were ordinarily brought from the mountains; where they were considered as a calamity; and the expression "pœnasque montium," clearly indicate that they were almost peculiar to the mountains.

Virgil directs the husbandman to plow in the first months in the year, and to pray for moist summers, and serene winters; for, says the author, the *winter's dust* increases the crop. This passage is no inconsiderable proof that the earth in some parts of Italy was not usually covered with snow in winter.

The winters described by Livy, when the Tiber was covered with solid ice; when the snow lay in the streets of Rome for forty days; and in Spain, was four feet deep for thirty days; when men, cattle and trees perished, were singularly severe, like our modern winters of 1642, 1709, 1741, 1780, which happen but two or three times in a century. Any man will be convinced of this, who attends to the description of them in the original authors. I find they happen in modern days, as frequently as at any former period. Scarcely three or four such winters are described in the whole history of Rome, down to the age of Julius Cesar; though many others happened, as may be collected from circumstances.

The severe winter of the year of Rome 354, is expressly declared by Livy to be a remarkable event. "*Insignis* annus hieme gelida ac nivosa fuit; adeo ut viæ clausæ, Tiberis innavigabilis fuerit"….Lib. 5. 13. He calls it also " tristem hiemem;" and it was followed by terrible pestilence. Nothing can be more clear, than that such a winter was an extraordinary occurrence. Without considering it in this light, the word " insignis" has no meaning; and instead of proving the usual temperature of winter at Rome to have been severe, it is the strongest evidence to prove that the winters were *generally* mild, and the Tiber navigable in the winter months. Had this been a common winter, or any thing like it, it would not have been singled out by the historian as a subject of remark. This explanation is applicable to all the instances of cold winters, described by historians. Even the passage in Juvenal, if it proves any thing, confirms the opinion that the frost, in his days, was not ordinarily very severe. The circumstance of a woman's breaking the ice in the morning to bathe in the Tiber, indicates that the ice was usually thin and easily broken; and by no means admits the supposition of ice a foot thick, like that which covers our rivers. It supposes a thickness of ice which is often seen on the Tiber at this day, frozen in the night, and dissolved the next day.

All the Roman writers speak of severe winters by way of distinction. Virgil says, " sin duram metues hiemem"—if you apprehend a hard winter. And Horace attempts to dissuade Augustus from his design of resigning the empire, by describing the severe cold, snow and hail of the winter, which he represents as prodigies, and evidences of the resentment of the gods. The winter to which he refers was probably of unusual severity. I apprehend the great source of error on this subject has been, that the moderns have taken for representations of ordinary winters, those which were intended for a few rare occurrences. Certain it is that the common winters of Italy were not severe, but mild. This I will demonstrate by a series of evidence, drawn from the phenomena of the natural world, which cannot deceive us in regard to climate.

Pliny, in his Natural History, lib. 2. 47. has given us an account of the winds in Italy. Among other things he informs us directly that the " spring opens the navigation of the seas, in the beginning of which, Favonius, the west wind, mitigates the severity of winter, about the time when the sun enters the 25th degree of Aquarius. That time is the 6th day before the ides of February." This was the 8th day of the month, and this was accounted the beginning of spring. Virgil, in his 3d Georgic, confirms this declaration of Pliny, and speaks of the commencement of the rainy season, that is, the spring rains, about the last of January.

..................................." Cum frigidus olim
Jam cadit, extremoque irrotat Aquarius anno"—

when cold Aquarius now sets and sprinkles his dews, at the close of the year. This refers to the old Roman year which ended the last of February, the month when Aquarius set. The name of this sign indicates that the season was *rainy ;* and the testimony of both these authors concurs, in proof that the winter was considered at an end, the beginning of February.

Aquilo, the northeast wind, began to blow, about the setting of Pleiades or the seven stars, which was near the 3d of the Ides of November, answering to the 10th day of the month....Pliny. lib. 2. 47.* This was the introduction of cool weather. The Septentrio, or north wind from the Alps, was the coldest wind, and blew mostly in December and January.

Severe winter weather set in about the last week in December. The halcyon days were seven days before and as many after, the winter solstice, when the kingfisher was said to tranquilize the sea. This period of mild or calm weather seems to have resembled our "Indian Summer," a period of fine weather that often happens just before winter. The fable of the halcyon days is no inconsiderable proof, that the winter did not set in with rigor till after the winter solstice.

* By the precession of the Equinoxes, that constellation now sets about three weeks later, or the first week in December. But our modern Calendar corresponds nearly with the Julian Calendar in Pliny's time. The name *Aquarius*, given by the Romans to the sign which the Sun passes in the midst of winter, demonstrates that rain and not snow, predominated as the characteristic of that month.

But the best evidence of the true temperature of the climate of Italy, and the course of the seasons, is that which arises from the time of vegetation. This is infallible evidence.

Pliny relates, Nat. Hist. lib. 16. ca. 25. that spring began with the blowing of Favonius. This time is expressly fixed to have been the 8th of February. Pliny calls it the "genial breath of the world." This author informs us that some vegetables germinated on the first blowing of this wind. "Primo favonio germinat Cornus, proximus laurus, pauloque ante Æquinoctium tilia, acer." The cornelian cherry germinates on the first blowing of the west wind; afterwards the laurel, and a little before the equinox, the lime tree and the maple.

In the fifth chapter of the 18th book, he says, "some persons prefer planting gourds about the first of March, and cucumbers about the nones," or middle of the month. In the 34th chapter of the same book, he says "Favonius begins the spring; it opens the earth, being moderately cool and salubrious. It directs the husbandman to prune his vines, to take care of his corn, to plant trees, to graft apples, and tend his olives."

Spring radishes, says the same author, are to be sown after the ides of February; but this plant, he adds, is so fond of cold weather, that in Germany it grows to the size of a *little boy*. Gardens are to be plowed, according to the same author, about the ides, the 13th of February.

Horace, Ode 4th of Book I. expressly says, that spring begins by the favor of Favonius, when the cattle no longer seek their stalls, the husbandman his fire side, nor are the meadows any longer whitened with frost.

These facts indicate a moderate climate, like that of the Carolinas and Georgia in America; and they could not be true of a climate where common winters were long and severe.

The real temperature of Italy is ascertained precisely by the olive and other plants, that we know will not bear severe frost, and will not thrive and come to perfection, but in warm climates.

The olive tree has been known in Greece from time immemorial. See Theophrast's history of plants, Lib. iv. and v. and notes. At what time it was introduced into Italy, is not recorded. Fenestella, says Pliny, relates that in the age of Tarquinius Priscus, the olive was not known in Italy, Spain or Africa. It was however cultivated in all parts of Italy, in Spain and Gaul, long before the christian era....*Plin. Nat. Hist. lib.* xv. *ca.* i.

We have then the data to ascertain the ancient climate of Italy with great precision. In our country, olives will grow well in Virginia, but frosts are too frequent and severe to permit their cultivation, to any valuable purpose. In South Carolina, they are cultivated to advantage. Italy then has had, from very early ages, a climate as mild as that of South Carolina.

The fig seems to have been a native of Italy. Plutarch, in his life of Romulus, tells us, that Romulus and Remus were found under a fig tree, where they were nourished by a Wolf. Whether this was true or not, it is certain that the Romans paid a particular veneration to a fig-tree that was in the forum, " ob memoriam ejus, quæ nutrix fuit Romuli et Remi conditoris appellata," says *Pliny. Lib.* xv. xviii. If the fig tree is a native of Italy, the climate could never have been colder than the Carolinas in America. This evidence is incontestible, and it totally overthrows the modern hypothesis of the severity of the winters in ancient Italy. It is needless to swell this argument by mentioning many other fruits, as dates, pomgranates and others, that will not thrive in cold climates.

The same plants grew and produced abundantly in Thessaly and Macedonia; although the ancients represented the latter as a cold country. It was doubtless colder than Greece, perhaps colder than Italy; but certainly could not be much colder than the Carolinas in America.*

The time of sowing corn in Italy is a confirmation of what is here advanced. Virgil directs the husbandman

* Herodotus, in Thalia, speaks of the seasons in Greece as " agreeable and temperate."....*Sect.* 106.

to sow barley between the autumnal equinox and the winter solstice. Wheat was not to be sown till the last of October, and those who sowed earlier were disappointed of a good harvest....*Georgic* i. These facts all correspond with each other, and demonstrate that the climate of Italy was then mild, and nearly as mild as it is at present. The time of sowing wheat, it will be observed, was the same as in Palestine. Severe winters often occur now, as they did 2000 years ago. Several winters are on record within a few centuries, in which vines and trees perished with cold. The winter of 1709 killed trees in Italy ; as did that of 1757 in Syria. I can name a number of such winters within three or four hundred years.

No longer ago than 1788—9, the winter was so severe in Europe, that the rivers in Estremadura in Spain, and in Alantajo in Portugal, two southern provinces, and of the mildest climate, were covered with ice ; and the mountains of Asturia, Leon and Biscay were covered with deep snow, as late as the 6th of March. See the Gazettes of the year 1789. It should be remarked that Barcelona, near which the Romans found snow four feet deep, as already related, is in the northern part of Spain.

Dr. Williams, as a further evidence of a mitigation of the cold in modern winters, mentions the present state of the climate round Constantinople and the Euxine Sea, compared with Ovid's description of it in his days. Ovid was banished to Tomos, near the Euxine, in lat. 44, about the 7th year of the Christian Era, and died there in the 15th year, or perhaps the 16th. He mentions that the Euxine was covered with ice, which was a highway for man and beast, and that wine was offered to him in a state of congelation. All this might be true at the time he was at Tomos, and even frequently true, without supposing the climate essentially different from what it is at present. But when Ovid asserts that the snow, in some places, was not dissolved during the summer, we must understand him to refer to snow on the high mountains ; for all history testifies that the country about the Euxine, and far north, was, in Ovid's time, and long before, a fine grazing and corn country. Both Ovid and Virgil, when they speak of the Scythian country, as being always clothed with snow, must have intended the mountains; and we have the authority of Lady Montague, who travelled through the country along the Danube in 1717, that Mount Hæmus and Rodope are, in modern times, *always covered with snow*....Letter xxv.* These mountains are a degree and a half south of Tomos. Surely then we have no reason to think the climate has suffered any considerable alteration.

Dr. Williams mentions the year 401, when the Euxine was covered with ice for 20 days, as an evidence that the climate was formerly colder than at present; and notices the remark of Dr. Smith, in Phil. Trans. No. 152, that the Turks were greatly astonished at the appearance of ice at Constantinople in 1669; [Dr. Williams by mistake has 1667] and he then adds, "In all the adjacent country, instead of frozen sea, frozen wine, and perpetual snow, they have now a fine moderate warm climate."

Here again Dr. Williams has run into the error before mentioned, of taking the accounts of a few *severe winters* as descriptions of the *ordinary winters*. The winter of 401, in the reign of Honorius, was during the approach of a comet, and was noted for its severity, as an *unusual* occurrence. Any person may observe this, who will consult the original histories. Three hundred and sixty years later, viz. in 762—3, a still more severe winter covered the Euxine with ice and snow of 30 cubits thickness, which ice at the breaking up of winter, was impelled against the walls of Constantinople and beat down considerable portions of it.† This does not indicate any mitigation of the climate. A similar event happened in the reign of Achmet I. about the year 1613 or 14, which marked a severe winter and no mitigation of the climate. The winter of 1669, when the Turks were astonished at ice in the Bosphorus, was al-

* See Horace, Book ii. Ode. xxv. xxvi. Ovid. Metam. Lib. ii. ccxxii.

† Paul. Diac. lib. 22. Baronius. vol. ix. 272. Hoveden. 231.

so severe. These seasons are recorded as *rare occurrences*, and this was the fact in the fourth century, as well as in the 17th. Historians have taken no notice of ordinary seasons, either in ancient or modern times; but we are not to estimate the temperature of climates by a few cold winters.

Winters of severe cold still occur in Greece, fully answering to the descriptions of the winters of antiquity. Wheeler, in his travels, says, he was prevented from visiting mount Hymettus, two miles from Athens, by the snows in February; and found woollen garments hardly sufficient to defend him from the cold of the valleys. The rivers of Thrace also were covered with ice.

Another proof of the decrease of cold, mentioned by Dr. Williams, is that in ancient times, the Alps were almost impassable in winter, on account of the snow and ice; whereas in modern days, they are crossed without uncommon sufferings. This statement is a most unfortunate one for the argument. It is but three years since the French troops suffered incredible hardships in crossing mount Cenis into Italy, from most violent storms of snow; and the commander boasted in his dispatches to the government, that the republican troops had surmounted obstacles that appeared too great for human efforts. The Alps are now, as in Hannibal's time, subject annually to severe cold, and violent snow storms; altho the roads are doubtless better, and render a passage less difficult.

I am however surprized that the difficulties which Hannibal experienced from snow in crossing the Alps, should be mentioned in proof of the severity of the ancient winters; when it is expressly related by Livy, that no sooner had the army reached the foot of the mountains on the Italian side, than the horses and mules were turned out to graze, in a fine country and mild weather.* "Inferiora valles et apricos quosdam colles habent, rivosque prope silvas et jam humano cultu digniora loca. Ibi Jumenta in pabulum missa."....*Liv. Lib.* xxi. xxxvii.

* The mountains were covered with snow, but the rivers of Italy were not covered with ice. The Po, the Ticino and the Trebia were crossed by bridges.

This was in November. Let us see then whether the climate of the Alps is mitigated.

In 1789, Arthur Young met with a snow storm and freezing weather in the plains of Sardinia on the 13th of December. The next day, the frost was severe, the snow deep, and ice five inches thick, near Alexandria. On the 21st he crossed mount Cenis, on snow *ten feet deep*. On the 25th he reached Chamberry, and there was a thaw....See his Tour in France, vol. i. 516, 527, 530, 537. There is not a shadow of reason to suppose the least melioration of that climate within 2000 years.

The next series of facts to prove a great mitigation of the cold in winter, consists of what authors have recorded of ancient Gaul and Germany.

Diodorus Siculus, lib. 4, relates that "Gaul is infested with cold to an extreme degree. In cloudy weather, instead of rain, great snows fall; and in clear weather, it freezes so excessively, that the rivers are covered with bridges of their own substance, over which large armies pass with their baggage and loaded waggons. And there being many rivers in Gaul, the Rhone, the Rhine, &c. almost all of them are frozen over; and it is usual, in order to prevent falling, to cover the ice with chaff and straw."

"North of the Cevennes," says Strabo, "Gaul produces not figs and olives; and vines which have been planted, bear not grapes that will ripen"....*Lib.* 4.

"Colder than a Gallic winter," was used by Petronius as a proverbial expression, says Hume....*Vol.* i. 459. *Essays.*

"The Rhine and the Danube," says Gibbon, "were frequently frozen, and capable of sustaining the most enormous weights. The barbarians often chose the winter to transport their armies and cavalry over a vast and solid bridge of ice. *Modern ages have not presented an instance of a like phenomenon*"....*Vol.* i. *ch.* 9.

The last assertion of Gibbon is contrary to all historical evidence, and even to facts which took place during that author's life.

In opposition to Gibbon's assertion, I affirm then, that both the Rhine and the Danube have, within three centuries, been frequently covered with ice sufficient to sustain the largest armies that ever issued from the north.

Dr. Williams has copied these remarks of Gibbon; and it is a most unfortunate circumstance for the author and the transcriber, that the very winter after Dr. Williams published his History of Vermont, the French troops crossed the Rhine into Holland *on the ice.* The rivers and canals were all converted into bridges in January 1795....See the speech of citizen Paulus to the Provisional Convention, January 26—State Papers, vol. iii. The cold was unusually severe; the event was an uncommon one; but it is one that happens in hard winters, a few of which occur every century.*

It appears by interrogatories made by the Stadtholder on the 18th of January 1795, to his naval officers, that the Prince could not escape from Holland by any of the rivers of that country—the eastern and western Ems, the Elbe and the Weser, being obstructed by ice....*State Papers, vol.* iii.

With respect to the other part of Gibbon's assertion, that the barbarians chose the winter season to make inroads into southern countries, because they could pass on the ice, I can readily believe this might have happened many times. From his acquaintance with the original historians, he was certainly well qualified to make the assertion. Some instances of this fact are recorded. I find in Cesar's History of the Gallic War no instance of this sort; but many instances of Roman armies and barbarians crossing the great rivers on bridges. Cesar was obliged to build bridges, at two or three different times, to throw his troops over the Rhine. Had the freezing of that river been an annual event, he would have taken the advantage of a bridge of ice.

That the Rhine did not freeze every winter, we have positive evidence, in the 4th book of the Gallic War. During the winter of the year 55 before the Christian era, two German nations attempted to invade Gaul, but were

* This event happened so opportunely for the purposes of the French, that even atheists were disposed to admit the existence of a God, for the purpose of arranging this event among the interpositions of heaven in their favor.

prevented by the want of boats. They employed a stratagem, and took possession of the boats belonging to the people or nation that inhabited the banks of that river, and by this means passed over, and subsisted for the remaining part of the winter, on the provisions they found on the other side. If the freezing of that river was a very common event, it is singular that Cesar, in all his wars in the adjacent countries, had not one occasion to mention the circumstance.

Cesar, in his 7th book of the Gallic War, mentions a winter campaign he made to quell an insurrection in the south of France. He was obliged to cross mount Cebenna, now Cevennes, in Languedoc, cutting a way through snow six feet deep. From this description of the snow, a superficial reader would draw the conclusion that the climate was intensely cold. Yet this was not the fact; for the river Loire, in the neighborhood, was not frozen so as to sustain troops; and in the siege of the town of Avaricus, Cesar relates, that the town was protected by a river and a morass.

The truth is, the mountain where the snow was then six feet deep, is high, and is annually covered with deep snow in this age; while the plains below enjoy a fine warm climate, that brings figs and olives to perfection. For these facts, I have the authority of Busching.... Abridg. vol. 5. and Arthur Young. Pinkerton describes the snows of these mountains in the following terms. "These mountains are in winter exposed to dreadful snowy hurricanes, called *acirs*, which, in a few hours, obliterate the ravins and even the precipices, and descending to the paths and streets, confine the inhabitants to their dwellings, till a communication can be opened with their neighbors, sometimes in the form of an arch under the vast mass of snow." This surely proves no moderation of the winters in France.

But let us attend to the vegetables which in the Augustan age flourished in Gaul. These, after all, are our safest guides.

Strabo says, Gaul produces not figs and olives north of the Cevennes; and grapes do not come to maturity.*

Diodorus Siculus goes further, and asserts that Gaul produces neither figs nor olives....*Lib.* 5.

Strabo is correct, as to figs and olives; for they will not come to perfection, at this day, north of the Cevennes.

Diodorus Siculus is an author of less credit, and in the instance before us, we have proof of his inaccuracy.

Pliny, whose authority in this case must be indisputable, expressly mentions the wine made in Auvergne, Languedoc, Dauphiny, Burgundy, and French Comptè. "Jam inventa vitis per se in vino picem resipiens Vinnensem agrum nobilitans, Arverno, Sequanoque, et Helvico generibus non pridem illustrata"....*Lib.* xiv. *ca.* 1. This species of vine, he observes, was unknown ninety years before, in the age of Virgil; and consequently was not known to Diodorus Siculus, who was cotemporary with Virgil. Strabo lived somewhat later, and had more correct information. This wine constituted the glory of that part of France formerly inhabited by the Allobroges, now called Dauphiny and Viennois, extending on the east side of the Rhone, from the Lemanic lake to its mouth, and was highly valued at Rome.

Pliny expressly mentions a species of the olive which thrived in Gaul beyond the Alps. "Quæ nunc provenit trans Alpes, quoque, et in Gallias, Hispaniasque medias."....*Lib.* xv. 1.

Strabo says the olive will not produce fruit, to the north of the Cevennes.

It is remarkable that the limits of the olive region, here designated, are precisely those to which that tree is now confined. The line, beyond which olives will not pro-

* It is well known that there are many varieties of grapes, and some far less hardy than others. The Romans might attempt to propagate, in the north of France, some varieties which thrived well in the south, and in Italy, but which would not come to maturity in a climate eight or ten degrees farther north; and from some instances of failure, might conclude that no vines would come to perfection in that country. I believe there are many varieties now cultivated in Italy and Greece, which would not come to perfection in the north of France.

duce fruit, as marked by Arthur Young, begins at the foot of the Pyrenees, in Rousillon, in the 42d degree of latitude, thence runs north-east, through Languedoc, to the southward of the Cevennes, crosses the Rhone at Montelimart, and pursues its direction, near Grenoble, towards Savoy, where it terminates. This district then includes part of Rousillon, part of Languedoc, most of Dauphiny, and all Provence. Olives grow and mature there precisely within the limits, marked by Strabo and Pliny, and as far as we can judge, not a league further north than they did eighteen hundred years ago.

I am willing to rest the whole argument on this fact. It is possible that the clearing and cultivation of particular places, by removing moisture, may enable the moderns to raise particular plants, as the vine, for example, in those places, where the ancients could not. But I do not find, in history, any evidence that a change of climate generally has carried any of the delicate fruits into latitudes where they did not thrive in the earliest ages. If any climate has become warmer by seventeen degrees, it would admit plants to be removed northward about ten degrees of latitude. For instance, the mean temperature of South Carolina is 66° by Farenheit; that in Connecticut, is about 49°, precisely the difference supposed by Dr. Williams to have taken place in the climate of Italy. The difference between the latitudes of Carolina and Connecticut is about 10 degrees. Ten degrees of latitude then give 17 degrees difference of temperature. If then olives grew in the south of France, eighteen centuries ago, and the climate has become warmer by 17 degrees, olives may have the same temperature now in 53° of latitude, that they formerly had in 43°. Of course they would thrive in Westphalia, Saxony and Prussia. Instead of which that tree is limited to Dauphiny and Languedoc, as it was at the Christian era.

The Roman writers speak of Gaul as a cold country. It certainly was colder than Italy, Greece, Africa, and Syria, the countries which were visited by the Romans, before they crossed the Alps. Accustomed to those mild climates, they were surprized at the rigorous winters of Gaul and Germany. They described the mountains of Thrace also, as covered with eternal snow ; yet Thrace was a fine country, and vines flourished on the borders of the Hellespont. The mountains were cold in winter, in Italy, Gaul, and Thrace ; but the growth of certain delicate plants, in those countries, is a better criterion of the real temperature of the climates, than the descriptions of poets and historians.

The winters in Gaul were colder than in England, according to the express testimony of Cesar....*Lib.* v. So they are at this day. If the general temperature of Europe has moderated in 1800 years, Britain, though an island, must have shared in the mitigation of cold. Yet we cannot admit any considerable change on that island; for Tacitus, Life of Agricola 12, expressly declares that it enjoyed a moderate climate in his days. "Asperitas frigoris abest." The mean temperature of England now is about 48°. If the cold has moderated within 18 centuries, as much as Dr. Williams supposes it has in other European countries, the climate formerly must have been intolerably cold, contrary to the testimony of Tacitus.

Another argument in favor of a great mitigation of cold in Europe, used by Buffon, and copied by Gibbon and Dr. Williams, is the retirement of the Rane* (deer) from the south of Europe, the Pyrenees and the forests of Germany, into the colder regions of Norway and Russia. Buffon asserts that this animal will not multiply and cannot subsist, south of the Baltic.

I consider this argument as very fallacious. The Rane seeks the forest, and flies before the ax of the cultivator, like the bear, the common deer, and the Indian of America. How can the deer subsist in open fields? We might as well expect a fish to live in air, as the rane in a country destitute of woods, and frequented by man. The Hyrcanian forest no longer exists; the husbandman has deprived that animal of his shelter, his food, his element. He does not like the company of man, and

* This is the true name of this animal, by an egregious corruption called *Rein-Deer*.

has abandoned the cultivated parts of Europe. It is just so with the common deer of North America, the bear, and other wild animals. The deer used to be found along our sea coast, and on the neighboring islands; but for fifty miles from the shore, at this day, not a deer is to be found;* and in a century, not a bear nor a deer will be seen on the south of the lakes. But will any man ascribe this desertion of the country to their love of cold? Not at all. It is their love of the wild forest, and not of cold, which impels them to recede before the arts of cultivation. How could the rane subsist in an open, cultivated country, when it is well known that his favorite food is a species of lichen [rangiferinus] which grows only or chiefly on heaths and uncultivated hilly grounds? Instead of proving a change of climate, the retirement of the rane seems to have been the natural consequence of of cultivation.†

But Gibbon's assertion that the Rhine and the Danube, in modern ages, have not been covered with ice, strong enough to sustain loaded carriages, must not pass uncontradicted. I know not what ages precisely, that author intended to include in the description of *modern*; but both the rivers mentioned have *often* sustained men and carriages on the ice within the *two last centuries*, as well as in preceding ages. In 821 and 994, history expressly mentions this to have been the fact. In 1233, the rivers in Italy sustained the heaviest loads on the ice; of course the Rhine and Danube must have done the same. The fact is also recorded of the year 1306; and in 1363 the Rhine was covered with solid ice for ten weeks. In 1402 the Baltic was passable on the ice for six weeks; and we may well suppose the Rhine and Danube were not open. I have no particular account of the effects of the rigorous cold of 1608, 1610, 1664, 1684, 1698, 1709, 1716, 1740, 1763, 1776, on those

* These animals found shelter in the immense barren plain on Long-Island; and are not yet driven from that spot by the hunters.

† King Alfred, in relating the story of Octher, who seems to have been a native of Sweden or Lapland, mentions 600 ranes as a part of his wealth, and speaks of the animal as if he had never before heard of it....*Alf. Oros. lib.* 1.

particular rivers; but the general accounts describe these and many other winters, during the two last centuries, as converting *all* rivers into highways for carriages, even as far south as Italy and Spain. But I have better proof of the fact. It is well known that the winters in England are *much milder* than in the same latitude on the Continent. This is always the case, and an undeniable fact. Now I have accounts that the Thames at London has been covered with solid ice, equal to the support of the heaviest loads, not only in most of the years mentioned, but in many others, during the two last centuries. From ten to fifteen or twenty rigorous winters occur, in every century, which convert most of the *small* rivers of Germany, France and England into highways; and several winters, in every century, produce the same effect in all the *large* rivers.

No longer ago than 1717, when Lady Montague travelled from Vienna to Constantinople, in the midst of winter, the navigation of the Danube was interrupted by the ice. In a letter dated at Belgrade Feb. 12, O. S. 1717, that lady says, " The weather is colder than I believe it ever was any where but in Greenland: We have a very large stove constantly kept hot, and yet the windows of the room are frozen on the inside." Between the date of that letter and the first of April, O. S. she pursued her journey to Adrianople, during which time, that is in March, she expressly says, " The Danube was now frozen over"....*See her Letter of April* 1.

This was not a winter of the greatest severity, though in England something colder than ordinary....See Short on Air, vol. ii. 20. The preceding winter had converted all rivers into bridges, even in Italy. What shall we then say to the assertions of such celebrated men as Gibbon? and what shall we think of the modern philosophy, erected on the authority of a few superficial inquiries?

The climate at Constantinople is milder than on the Danube; and in January 1718, Lady Montague sat with her window open, enjoying a fine warm sun....Letter 38. But this was an uncommon occurrence. In 1751, the people of Constantinople predicted the plague which raged terribly that year, from the *great snows of the prece-*

ding winter....Chenier's Morocco, vol. ii. 275. Indeed one single fact will demonstrate that the air at Constantinople is usually in winter below freezing point; which is, that winter always puts an end to the ravages of the plague—an event that rarely, if ever, takes place there without frost. But Constantinople is subject also to severe frosts, in hard winters, like all other northern countries; although the weather there, from the vicinity of the city to large bodies of water, is much less severe than in Hungary, Austria and Germany.

Men are led into numberless errors by drawing *general* conclusions from *particular* facts. "Lady Montague sat with her window open in January 1718, and therefore there is little or no winter in Constantinople," is very bad logic. The farmers on Connecticut river plowed their lands, as I saw, in February 1779; and the peaches blossomed in Pennsylvania. What then? Are the winters all mild in America? Not at all; in the very next year, not only our rivers, but our bays, and the ocean itself, on our coast, were fast bound with ice.

In 1592 the drouth was so severe that the Thames was fordable at London. In 1388, the Rhine was fordable at Cologne; and in 1473, the Danube was fordable in Hungary. Suppose in some future age, these facts should be alledged, as evidence of a wonderful increase of rains and moist weather, within the two last centuries; would such conclusions be just? Yet this is the reasoning which has principally supported the hypothesis of a modern diminution of cold in winter. Authors have mentioned and described the severe winters; while ordinary seasons have passed unnoticed; and this is the source of a great error in philosophy.

But scanty as our materials are for a history of the seasons in antiquity, we have a direct authority that mild winters occurred in the latitude of Constantinople, more than 2000 years ago.

Hippocrates, during the plague in Athens, B. C. 430, resided on the island of Thasus, which is in the Ægean Sea, near the coast of Thrace, a cool country, and near the latitude 41°. This author has left a minute description of the seasons for four years, with the current diseases. The first of these winters was *mild like spring, with southerly winds.* The second winter northerly winds prevailed, and great rains, attended with snow. This seems to have been a *common* season. The third winter, the weather was northerly, the cold severe, and the snow deep. This seems to have been a hard winter, and if I am not deceived in the chronology of events, this was within a few months of the appearance of a comet, and the great eruption of Etna mentioned by Thucydides.

The fourth winter was mild, with southerly wind, except a period of severe cold about the equinox, in March.

This authority is indisputable, that the winters in ancient times, were, as they are now, irregular and various; and instead of being uniformly rigorous, some were mild as spring.

In later periods, I find occasional mention of mild winters, although little notice has been taken of seasons, except when extraordinary for cold. The winter of 802 was southerly, mild weather, followed by the plauge. Mild winters are also mentioned in 1186, 1248, 1281, 1284, 1428, in some of which people wore summer clothes the whole winter, and in one instance harvest, in northern latitudes was in May, in consequence of the warm weather in the winter preceding. These winters were antecedent to any great improvements in agriculture in Europe.

It may not be improper here to introduce a fact related by Theophrast, of a change of temperature in Thessaly.

The river Peneus winds through a charming valley in Thessaly, and between the mountains Olympus and Ossa, finds a passage to the Ægean sea. This passage, the ancients alledged, was opened by an earthquake; before which the valley was covered with stagnant water. The draining of this valley is said to have rendered the country more healthy, but at the same time, the air became colder. In proof of this, authors alledge that olives, which before had flourished, about Larissa, would not endure the severity of the winters, after the valley was drained, and vines were often froze, which before was never known to happen....*See Anacharsis, vol.* iii. 341.

Whatever foundation may exist for this opinion, it seems the inhabitants had an idea that their climate had become *colder*, instead of warmer ; and it is well known that places surrounded by water have a milder climate, than others remote from water. This, by the way, is the principal reason why Greece and Italy are more temperate than other countries under the same parellels of latitude.

Let us now attend to the evidence of a mitigation of the cold of American winters. The first proof adduced by Dr. Williams, is what Kalm says, that on the first settlement of Philadelphia, the Delaware was commonly covered with ice about the middle of November, old style, corresponding with the last week of the month, in new style. But, says our author, " it is not now commonly covered with ice till the first week in January".... *Hist. Vermont*, p. 58.

Unfortunately for the argument, that river has been covered with ice for three years last past, not only by the middle of November, *old* style, but in one or two of the years, by the middle of that month, in *new* style.

Dr. Williams quotes Smith's history of New-York to prove his doctrine; the page is not mentioned, but I suppose the passage to be a note in the margin of page 82, where the author says " The climate of late is much altered, and this day, Feb. 14, 1756, three hundred recruits sailed from New-York for the army at Albany, and last year a sloop went up the river a month earlier."

It is thus men are misled by founding general opinions on particular facts. The truth I find to be, that at the period mentioned, there were two or three winters in succession the most mild that were recollected by the oldest men ; and all the world cried out, what a change of climate ! A few years however changed the common opinion, and a few such winters as 1780, 1784, 1796—97—98 and 1804, will leave very little room to believe in a change of climate.

Smith however, when he wrote the foregoing note, was writing in the text of his history, that Governor Fletcher sailed from New-York for Albany on Feb. 13th or 14th, in 1693. This certainly was a rare event, but it should have made him doubtful at least of a change of climate. Another fact cited by Dr. Williams, is, that Baron Lahontau put to sea from Quebec in 1690, on the 20th of November, new stile, the like of which had never been known in that place before. The St. Lawrence had been covered with ice on the 14th of November, but was cleared by a sudden thaw. Yet what conclusion can be drawn from the fact? Simply this, that the seasons then were sometimes very variable, as they are now. But Dr. Williams infers from this passage of history, that the St. Lawrence was, in former times, usually closed with ice by the middle of November; whereas in modern days, he says, it is not frozen over till the latter end of December or beginning of January. But this inference is probably drawn from some mild winters. In one fourth of our winters, the Hudson, Delaware and Connecticut are closed with ice in the 42d and 43d degree of latitude, as early as the last week in November, or first week in December; and it is against all probability that the St. Lawrence, in the 46th degree, continues open a month later.

In proof of his opinion, Dr. Williams cites a passage from Wood's Prospect, a work written in the early settlement of this country, which says, that the winters then began in December, and continued to February 21 (new stile,) when the rivers and bays were unlocked by warm weather; the duration of winter then was two months or ten weeks. This is mentioned to have been a very regular occurrence for ten or twelve years.

From this passage the author concludes the bays about Boston, on the first settlement of New-England, must have been "annually covered with ice," and that this bridge lasted through the winter months: Whereas in these days, this is not a regular event, nor when froze, does the ice continue so long. From data which he supposes sufficiently correct, he concludes that our climate has suffered a melioration in winter of ten or twelve degrees.

But we have here another instance of the fallacy of such general conclusions. In the first place Wood does not say that during the ten weeks of winter, the ice was never broken up by thaws, as it is in modern times; on the other hand, his expressions fairly intimate that such thaws were common; for he observes that about the 21st of February, the rivers and bays are unlocked, and "are never again frozen the same year." This expression doubtless alludes to the well known and common occurrence, that rivers, cleared of ice at an earlier period, were covered with ice again, in the same winter.

But that such thaws occurred, at that period, I have direct proof from Winthrop's Journal. In 1634, December 4th, old stile, a violent snow storm was followed by a severe frost that covered Boston bay with ice in two days, but "it was free again before night." In the middle of January, a pinnace came to Boston from Port Royal; and about the end of the month, a boat coming from Deer's Island was detained at Bird's Island; and also others were detained at an Island in the harbor by the ice, which was not sufficient to bear a man. After that the ice was firm for two or three weeks. This was no uncommon occurrence; a "January thaw" is a proverb handed down to us from our ancestors. That was a hard winter, yet many persons fell through the ice and were drowned.

But our ancestors had also mild winters, which made little or no ice in rivers or bays. Such was the winter of 1633—4, next preceding that last mentioned. Winthrop says expressly "this winter was mild, little wind and most S. and S. W." The last of February, fell a deep snow, but the winter was at an end. This is decisive evidence that the winters have been from the first settlement of America, variable, now mild, now severe, just as they are in the present age.

In 1635, Connecticut river was closed with ice November 15, old stile [26] at Hartford, but at Saybrook, not till December 10th [21]. This was a severe winter.

A ship from Bristol entered Boston Bay in January 1637, and by stress of weather was driven into Plymouth harbor.

In 1638, on the 13th of January old stile, [the 24th] Boston harbor was open; for thirty men went down to Spectacle Island to cut wood. A snow storm arose, in the following night, after that the wind was at N. W. for two days, and then, says Governor Winthrop, "it froze so hard, as the bay was all frozen up, except a little channel." By this opening twelve of the men got to the Governor's garden; others escaped on the ice. Of this winter the Governor writes, "This was a very hard winter. The snow lay from November 4, [15th] to March 23d [April 3d] one and an half yard deep about the Massachusetts," &c....*See pages* 146, 154. Let it be observed, that in this "very hard winter," Boston harbor was open till the 24th of January.

Note....In page 154, it is said this was in 1637. But it is immaterial.

The winter of 1641—2 was one of the most rigorous kind, like that of 1709, 1741 and 1780. It froze the bay at Boston as far out at sea as the eye could reach; loaded sleds passed from Muddy River to Boston. All the rivers in Virginia, and even Chesopeak Bay, were covered with ice. These things are recorded by Governor Winthrop as *extraordinary occurrences*, such as passing on the ice from Pullen's Point and Muddy River to Boston—a proof that the several frosts supposed by Dr. Williams were not annual events. And the Indians declared that a like winter had not happened in forty years preceding.

The next winter was milder than usual, and the winter following there was "little rain and no snow till March 3"....*Winthrop, p.* 240, 269, 324.

In an account of the Natives of New-England, written by Governor Winslow, and annexed to Dr. Belknap's 2d vol. of American Biography, we have the following description of the climate of New-England, in 1624:— "For the temperature of the air, in almost three years experience, I can scarce distinguish New-England from

Old England, in respect to heat and cold, frost, snow, rain and wind."—"Experience teaches us, that if the heat does exceed England, it is so little as must require better judgments to discern it. As for the winter, I rather think, *if there be a difference*, it is both sharper and longer in New-England, than Old; yet the want of those comforts in one, which I have enjoyed in the other, may deceive my judgment also." "The seed-time beginneth in the midst of April, and continueth good till the midst of May." This was written at Plymouth, a place whose heat in summer, and cold in winter, is moderated by the air from the sea. But the description does not warrant the idea of excessively cold winters. Seed-time was as early then as it is now.

In an account of the climate, soil and produce of New-England, written by the Rev. Mr. Higgeson, of Salem, in 1629, we have the following description of the seasons. "In the summer time, in the midst of July and August, it is a good deal hotter than in Old England; and in winter, January and February are much colder, as they say; but the spring and autumn are of a middle temper. In the winter season, for *two months* space, the earth is commonly covered with snow, which is accompanied with sharp, biting frosts, something more sharp than in Old England, and therefore we are forced to make great fires"....*Historical Collections, vol.* i. 117.

This description answers well for the ordinary seasons in New-England at the close of the 18th century. The summers are hotter; the winters colder than in England. A winter of eight weeks or two months frost, may be considered as a medium winter, between our very mild and very severe winters.

From the same narrative, it appears that maiz thrived as well then, as it does now, in the plantations about Salem, and produced the most abundant crops.

In a tract written in 1642, called "New-England's First Fruits," the climate is thus represented, in answer to some objections that had been made to the project of settling the country. "True, it is sometimes cold, when the wind blows strong at northwest; but *it holds not long* *together, and then it useth to be very moderate"....Hist. Col. vol.* i. 249.

The writer mentions the purity and wholesomeness of the air, and the bright, clear, fair weather, which are preferable to the moist, foggy, cold air of Holland and England. This account of the seasons answers well to the state of the weather in our days.

But I have a further remark to make on the passage cited from Wood's Prospect. This writer does not say that Boston Bay and Charles River were annually froze for eight or ten weeks. His words, if rightly quoted, are, " For ten or a dozen years, the weather hath held himself to his day, unlocking *his icy bays and rivers*, which are never frozen again the same year." These words do not authorize Dr. Williams to suppose the writer meant Boston Bay and Charles River at Boston. He might have had in view more inland bays and rivers; and indeed he must have had; for it is proved by Winthrop's Journal, an unexceptionable authority, that Boston harbor was not always nor generally froze in the midst of winter. If Wood then meant inland rivers and arms of the sea, his description is exactly true, at this day. I can aver, from thirty years observation, that Connecticut River at Hartford is a bridge of ice, on an average, eight or ten weeks in a winter; rather more than less; that is, from the beginning or middle of December to the 20th of February. This is the precise time mentioned by Wood; and the passage, instead of favoring Dr. Williams's opinion, is direct evidence that there has been no sensible diminution of cold in America, since its settlement.

In Winthrop's Journal I find a confirmation of this opinion. In page 23, there is a remark like that of Wood before cited, that " ever since the bay has been planted by the English, viz. *seven years*, it hath been observed, that at this day [February 10th, old stile, 1631] the frost hath broken up every year." Fortunately we have in this Journal full proof that the remark was not intended to represent the breaking up of a bridge of ice over the bay of Boston or Charles River.

On the 22d day of December, O. S. Governor Winthrop writes thus : " Till this time there was for the most part, fair open weather, with gentle frosts in the night; but this day the wind came N. W. very strong, and some snow withal, but so cold as some had their fingers frozen—three of the Governor's servants coming in a shallop from Mistick, were driven by the wind upon Noddle's Island"....*p*. 21. At this time then, the 3d of January, new stile, there was no ice in Charles River.

On the 26th, the Governor writes, " The rivers are frozen up, and they of Charlestown could not come to the sermon at Boston, till the afternoon at high water." By this we are to understand, that Charles River at the ferry was full of ice, which was removed by the flood tide, so that the river was passable in boats. This was on the 6th of January. On the 28th of December, O. S. the 8th of January, seven persons, says the Governor, set sail in a shallop, from Boston for Plymouth, and were cast away on Cape Cod. Boston harbor and bay must then have been open....*See p*. 21 *and* 22.

On the 5th of February, O. S. [the 16th] arrived the ship Lyon, at Nantasket. On the 8th [the 19th] the Governor went aboard the Lyon, then lying by Long-Island. On the 9th [20th] the Lyon came to anchor before Boston. On the 10th, O. S. [21st] says Governor Winthrop, " the frost broke up, and after that, tho we had many storms and sharp frost, yet they continued not, neither were the waters frozen up as before." The Governor then remarks, that for seven years before, the frost had broken up, on the same day of the month.... *See p*. 23.

This evidence is decisive to prove, that the breaking up of the ice was not said of the ice in Boston harbor; for the Governor went down to the ship Lyon, at Long Island, which is almost five miles from the town, and the ship came to anchor before Boston, *before the ice broke up*. Let it be noted also, that the severe frost, in that year, set in about Christmas, and broke up on the 21st of February; of course, it lasted about eight weeks, as in modern times.

It is obvious therefore that Gov. Winthrop and Mr. Wood, in the passages noted, speak of the breaking up of the rivers and frost in the country generally; and not of the ice in Boston harbor: And it is remarkable that the time mentioned is the same as that in which the winter of New-England, in ordinary seasons, now breaks up, viz. about the 20th of February.

I will only observe further on this point, that in Winthrop's Journal, which comprehends the events of fourteen years, from the first settlement of Boston, from 1630 to 1644, we have positive evidence that Boston harbor was usually open, and that vessels entered and departed in the midst of winter. The freezing of the bay, in the extremely severe winter of 1642, and the passing of loads on the ice, are described as *rare occurrences;* and what is more explicit, Governor Winthrop declares, " The frost was so great and continual this winter, that all the bay was frozen over so much and so long, as the like, by the Indian relation, had not been these forty years." Yet this frost lasted only from the 18th of January to the 21st of February, old stile, about five weeks....*See p.* 240. This evidence is decisive of the question, and utterly disproves the opinion of a change of climate. On the 18th of January, O. S. 1644, Boston harbor was open....*See p.* 321.

If Dr. Williams is unfortunate in his facts, he is still more so in his reasonings and deductions. The following is a specimen.

In 1782, the river between Boston and Charlestown was frozen, so that horses and sleys passed over, for five or six days. The ice was permanent from February 2d to the 10th. During that time the lowest point of cold by Farenheit was 9°; the highest 28°, and the mean of the temperature 13°. From this statement, the Doctor concludes, that the freezing of the bays mentioned by Wood about the year 1630, could not take place in a less degree of cold than 13°. He found from seven years observations, that the mean temperature of December was, in these years [from 1780 to 1788] 29° 4; that of January, 22° 5; and that of February, 23° 9. Hence he concludes, that the change of temperature at Boston since the year 1630 must have been from " ten to twelve degrees."

I confess myself surprized that so intelligent a man should not have observed the fallacy of this reasoning. He takes the mean of *seven or eight severe cold* days in 1782, which covered Charles River with ice, for the standard by which to estimate the cold of 1630, and the mean of the *whole winter*, as the standard of cold in modern days, by which to compare it. This mode of reasoning is all fallacious. In the first place, it is not true that a mean degree of cold, answering to 13° by Farenheit, is necessary to keep Charles River covered with ice. The effect would be produced with a much less degree of cold. Let the mercury sink to 10° for five days, and a bridge of ice would be formed. Then let the cold relax, and the mercury rise to 30° for five days. The mean temperature of the whole ten days would be 20°. Yet in this case probably, the ice would remain a solid bridge through the whole time, notwithstanding the rapid tides in that river. And in fresh water, where there is no current, the bridge would remain a much longer time, and in much milder weather. Indeed, I can prove that a river or pond of water may be covered with twelve inches of solid ice, when the *mean* temperature is not below freezing point. But I will not rest the argument on calculations; I appeal to facts.

In November, 1797, commenced a series of severe cold, altho the beginning of the month was as mild as usual. Towards the close of the month, the Hudson, Delaware and Connecticut were covered with solid ice; yet the mean temperature of the whole month, at the exchange at New-York, was 38° 87 by Farenheit, almost seven degrees above the freezing point. This fact exhibits the fallacy of the Doctor's conclusions....*See p.* 59, *of his History of Vermont.*

In page 383, Appendix, Dr. Williams states that in America, where the rivers are froze to a firmness sufficient to sustain heavy loads, the "mean heat of the winters is from 15 to 20 degrees." This is a most egregious mistake, and contradicts his own observations of the weather between 1780 and 1788, as before stated. The mean temperature of those seven winters was, by his own statement, 25° 2—and this corresponds nearly with the results of Dr. Holyoke's seven years observations at Salem, which make the mean temperature of the three winter months 25° 76. With this degree of cold, fresh water rivers are annually covered, and held bound with solid ice.

To cover with ice salt streams, bays and arms of the sea, a greater degree of cold is requisite, and this degree occurs many times every century.

If then a mean temperature of 25 or 26 degrees by Farenheit will keep the American rivers covered with ice for many weeks, we have further evidence that the Rhine and Danube, fresh water rivers, must be frequently froze in modern times. Dr. Williams states the mean degree of cold at several places in Europe, as follows:

At Vienna, in 1779 and 1780,	*January,*	27° 5
	February,	33 23
At Ratisbon, in 1781 and 2,	*January,*	30 52
	February,	30 76
At Manheim, in 1781 and 2,	*January,*	35 08
	February,	35 08

From these means he deduces the general mean of 31° 8 for January, and 33° 6, for February, which, he says, will accurately express the temperature of a German winter on those rivers. Admit this conclusion, and what follows? The undeniable consequence that a German winter is almost as cold as a New-England winter; for the mean temperature of January in Vienna was 27° 5—the mean temperature of an American winter is 25° 76. The difference is only *one degree and twenty-nine hundredths.* The difference between the general mean of January above stated, 31° 8, and the general mean of America, of 25° 76, is only 5° 32. If the vibrations of heat and cold are as great on the Rhine and Danube as in America, which is understood to be the fact, those rivers must be froze every winter, although perhaps not sufficiently in a common winter, to sustain loaded carriages. Certain it is that the cold at Manheim and Ratisbon is nearly equal to any thing experienced in New-England. In the Memoirs of the American Academy, part 1 of vol. 2, page 88, Dr. Holyoke has stated the greatest cold at Ratisbon, by a series of observations, to be 13° 45 below cipher by Farenheit, and the mean of the greatest colds, 2° 42 below cipher. At Manheim, the greatest cold was 8° 95 below 0, and the greatest mean of cold 1° 2 above 0. From all which it is obvious that no diminution of cold, equal to 16 degrees, can have taken place, since the Goths and Vandals invaded the Roman empire, as Dr. Williams supposes; for the cold which reduces the mercury by Farenheit's scale to 8 or 10 degrees above cipher, if continued only two or three days, must cover the Rhine and Danube with solid ice.

Before I conclude this subject, it is proper to notice what Mr. Jefferson has written on the climate of Virginia....*Notes*, *Query* 7. "A change in our climate," says this author, "is taking place very sensibly. Both heats and colds are become much more moderate, within the memory even of the middle aged. Snows are less frequent and less deep. They do not often lie below the mountains more than one, two or three days, and very rarely a week. The elderly inform me, the earth used to be covered with snow about three months in every year. The rivers which then seldom failed to freeze over in the course of the winter, scarcely ever do so now. This change has produced an unfortunate fluctuation between heat and cold in the spring of the year, which is fatal to fruits."

What evidence there is of a diminution of heat in summer, I do not know; but I find abundant evidence that no such diminution has taken place. And that no very definite proof of the fact has appeared, is very obvious from the difference of opinion on the subject. Mr. Jefferson supposes a *diminution* of the heat of summer. Dr. Williams supposes a general *increase* of heat in our climate; and I leave them to adjust the difference between themselves.

Mr. Jefferson seems to have no authority for his opinions but the observations of elderly and middle-aged people. But what shall we say to the following facts? Mr. Jefferson informs that in Virginia, the snow used to cover the earth about three months in every year. How shall we reconcile this account with the representation of the climate by Lord Delaware and Sir Thomas Gates, a few years after Virginia was first planted, A. D. 1611 or 12? In that account it is expressly stated, that "the soil is favorable for the cultivation of vines, sugar-canes, oranges, lemons, almonds and rice—*the winters are so mild that the cattle can get their food abroad*, and swine can be fatted on wild fruits....*See Purchas, vol.* v. 1758*: Belknap's Biography, vol.* ii. 39.

If this description of the climate is just, the seasons in Virginia were then just what they are now. In ordinary winters, cattle and swine will get their living in the woods; but in severe winters, they are liable to perish.

Perhaps Mr. Jefferson's observations refer to the interior and mountainous parts of the State, where by the clearing of the lands, the winters may have become less steady, and the snows less durable; but this is no proof of a general diminution of cold in the winter; it proves only more variable weather. The description given by the first settlers about 190 years ago, is decisive evidence that the general temperature of the climate was then the same as it is now; and that in its rude state, Virginia produced the delicate tropical fruits, as far north as they can be cultivated at this day. Had there been a general increase of heat in our climate, the cultivation of the fig and the olive would have advanced northward to Pennsylvania or New-England; but instead of this, not a plant has advanced a single league since the first settlement of the country.

To the testimony of Lord Delaware and Sir Thomas Gates, may be added that of Beverly, who in his history of Virginia, written at the beginning of the last century, says, "The rivers and creeks were, in many places, covered with fowl during the winter"—which precludes the fact that they were covered with ice....*p.* 134. "That elks, buffaloes, deer and other game," were hunted by the natives "in winter, when *the leaves were fallen and so dry, they would burn;*" the Indians driving them into a crowd, by circular fires....*p.* 136. In page 252, he alludes to the practice of letting cattle feed in the woods in winter, and charges his countrymen with ill husbandry, in not providing sufficiently for them all winter. In page 268 he says, the winters in Virginia are very short, continuing not above three or four months, of which thirty days are seldom unpleasant weather; all the rest being blest with a clear air and a bright sun. However, sometimes the frost is very hard, but it *rarely lasts more than three or four days*, before the wind changes. The rains, except in the depth of winter, are extremely refreshing and agreeable....*Lond. Edit.* 1722.

It appears to me extremely unphilosophical to suppose any considerable change in the annual heat or cold of a particular country. We have no reason to suppose that the inclination of the earth's axis to the plane of its orbit has ever been varied; but strong evidence to the contrary. If this inclination has always been the same, it follows that the quantity of the solar rays, falling annually on a particular country, must have always been the same. Should these data be admitted, we are led to conclude that the general temperature of every climate, from the creation to this day, has been the same, subject only to small annual variations, from the positions of the planets in regard to the earth, or the operations of the element of fire in the globe and its atmosphere.

The real truth seems to be, that when a country is covered with forest, the vibrations in the temperature of the air and of the earth near the surface, are less numerous and less considerable, than in an open country. Dr. Williams himself has furnished the data by which to determine this point. In 1791 he found an open field froze to the depth of three feet five inches; at the same time, in a forest, he found the temperature of the earth, to be 39° by Farenheit, seven degrees above frost. This fact solves the question here discussed.

While a country is covered with trees, the face of the earth is never swept by violent winds; the temperature of the air is more uniform, than in an open country; the earth is never froze in winter, nor scorched with heat in summer; and snow that falls in November usually lies till March or April, altho the earth below is not froze, but gradually melts the snow and absorbs the water. On the other hand, an open country is exposed to violent winds and frequent great changes of weather. The earth in winter is usually froze into a solid mass from one to three feet thick; great snows alternate with heavy rains; the earth which is covered with snow to-day, is to-morrow left bare; and an iron surface of this week, is, the next, converted into soft mud. Hence probably as much snow falls in an open country as in a forest; or if the clearing of a country converts more of the vapor into the water, yet it is liable also to more extreme cold, which preserves a balance in the temperature. That these are facts every man knows, who has observed the difference between the open country and the forest, in our old settlements; and Dr. Williams himself has given the results of meteorological observations which confirm them, and disprove the common theory of a moderation of cold. In page 50 of his history, he states the difference between the heat of the earth in an open field, and in the woods, during the summer; by which experiments, it is demonstrated, that from the latter part of May to the close of August, the open country sustains about ten degrees of heat, beyond that of the forest; the thermometer being sunk ten inches below the surface of the earth. At another time, he found the winter temperature of the earth in the forest to be 39°, while, in open field, the earth was froze. The vibrations therefore in the temperature of the earth, when cleared, are found to be much greater than when covered with wood. The differences, according to Dr. Williams, are as follows:

Winter temperature of the earth in the woods in Vermont, - - - - - - -	39°
of the open field at frost,	32°

Summer Temperature of the Earth.

		In an open field.	In the forest.	Difference.
May	23,	50°	46°	4
	28,	57	48	9
June	15,	64	51	13
	27,	62	51	11
July	16,	62	51	11
	30,	65 1-2	55 1-2	10
August	15,	68	58	10
	31,	59 1-2	55	4 1-2
Sept.	15,	59 1-2	55	4 1-2
October	1,	59 1-2	55	4 1-2

From these observations, it results that in winter the earth of the forest is seven degrees warmer than the open field; and in summer, it is, on an average, from May 23 to August 31, 9 1-4 degrees colder—and on an average, from May 23 to October 1, 8 1-4 degrees colder. That is, the vibrations in the forest temperature of the earth are between 39° and 58°—only 19 degrees of difference between winter and summer—while the vibrations in the temperature of the open country, are between 32, or frost, and 68—making a difference of 36° between winter and summer.

The vibrations of the temperature of the air, are more considerable; but it is an unquestionable fact that they are much greater in an open country, than in a forest; and so far is it from truth, that the clearing and cultivation of our country, has moderated the rigor of our cold weather, that the cold of our winters, tho less steady, has been most sensibly increased. There is not a greater amount of cold during the winter, but the cold at times is more severe than before our counrry was cleared. The difference is so sensible, as to be a subject of popular remark among aged people.

Another effect of clearing the country is to distribute the cold of the year more unequally: hence fruits are more exposed to spring frosts. This is a most serious inconvenience in Europe, and is becoming so in America. The reason of variable and late springs is obvious. While the earth is covered with wood, it is never froze, but as soon as the snow is dissolved in spring, vegetation begins. In an open country, after the snow is melted, the earth is to be thawed; and the heat of the air for two or three weeks, is incessantly absorbed by the earth and water, while the frost is dissolving. Hence the heat of a warm day in spring is speedily absorbed, and cold succeeds. This alternation must continue, till the earth is warmed. If the winter temperature of the earth in a forest is 39° and that of the open country 32, we may easily conceive what an immense quantity of heat it must require to raise the temperature of the open field to that of the forest. It must demand nearly all the heat excited by the solar rays in April, so that in our open country, the earth is probably not warmer on the last of that month, than it was, when a forest, on the first of the month.

It will be remarked that in discussing this question, I have admitted the fact assumed by my opposers, that there has been a clearing and cultivation of Palestine, since the settlement of the Jews in that country; and of Italy, since the days of Julius Cesar. But I must not quit the subject, without contradicting the fact assumed. The reverse is the truth.

When Joshua led the Israelites towards Palestine, that country was very populous, inhabited by various tribes of people, and containing large cities, whose enormous walls terrified the Israelites. Never has that country been so populous as in the few first centuries, after the Israelites took possession of it. The country therefore could not have been covered with wood, but every foot of cultivable land was occupied by husbandmen.

Equally true is it, that the countries on the north of Syria were as populous in the days of Darius, as at any subsequent period. It was the case also in Italy, which was more populous at the Christian era, than it has been for the last fifteen centuries. In all these countries therefore, no clearing of the lands can have taken place, to influence the climates, within the period in which a moderation of cold is supposed. Germany, on the north of Italy, has been, in a degree, cleared; but the Rhetian Alps intervene between Italy and Germany; and the cold winds which affect Italy in winter, blow from those high lands, where the air is colder than in the less hilly country on the north. In every point therefore, the hypothesis of a moderation of climate appears to be unsupported.

I would only further observe, that if the cold has abated ten or twelve degrees in our climate, within a century and a half, it must have been intolerable before that period. The mean temperature of Vermont now is about 43°. If we deduct 10° only for abatement of cold, the water in deep wells in Vermont, two hundred years ago, must have been of 33° of temperature, or nearly at the freezing point; in Canada it must have been at 32°, or the state of congelation. If we suppose the winter only to have changed, and deduct one half the supposed abatement, still the result forbids us to believe the hypothesis. If we suppose the heat of summer to have lessened in the same proportion, as just philosophy requires us to do, the summers formerly must have been intolerable; no animal could have subsisted under ten degrees of heat beyond our present summer temperature. On whichever side we turn our eyes, we meet with insurmountable difficulties.

From all I can discover, in regard to the seasons, in ancient and modern times, I see no reason to conclude with Dr. Williams, that the heat of the earth is increasing. It appears that all the alterations in a country, in consequence of clearing and cultivation, result only in making a different distribution of heat and cold, moisture and dry weather, among the several seasons. The clearing of lands opens them to the sun, their moisture is exhaled, they are more heated in summer, but more cold in winter near the surface; the temperature becomes unsteady, and the seasons irregular. This is the fact. A smaller degree of cold, if steady, will longer preserve snow and ice, than a greater degree, under frequent changes. Hence we solve the phenomenon, of more constant ice and snow in the early ages; which I believe to have been the case. It was not the *degree*, but the *steadiness* of the cold which produced this effect. Every forest in America exhibits this phenomenon. We have, in the cultivated districts, deep snow to-day, and none to-morrow; but the same quantity of snow falling in the woods, lies there till spring. The same fact on a larger scale, is observed in the ice of our rivers. This will explain all the appearances of the seasons, in ancient and modern times, without resorting to the unphilosophical hypothesis of a general increase of heat.

SUPPLEMENTARY REMARKS,

On the supposed Alteration of the Temperature of Winter:

WRITTEN AND READ BEFORE THE ACADEMY IN 1806.

WHEN the preceding Dissertation was written, I had devoted very little time to an examination of the subject, and had read very few of the authorities cited to prove a moderation of cold in winter in modern times. Since that time, I have noted such passages in ancient authors, as have occurred to me, in the course of reading, with a view to ascertain, if possible, the real fact, whether the industry and improvements of men, by destroying forests and cultivating the earth, have occasioned a material alteration of climate.

Strabo, in the first book of his geography, cites from Homer, whom he calls the father of geography, a passage which describes the climate of the western part of Europe, where the poet places Elysium....*See Odyssey, book* 4. This country, says the poet, experiences "no violent storms of snow, and little winter, but is perpetually refreshed by gentle zephyrs ftom the ocean." This description Strabo applies to Iberia, or Spain, and alleges that the *Fortunate* Isles received their name from their vicinity to this happy climate. The description proves at least the opinion of the ancients respecting the climate of Spain and Portugal, and it corresponds with the present state of the climate.

Polybius, speaking of an invasion of Peloponnese by Philip of Macedonia, about the year before Christ 218, mentions the hardships which his army encountered, in passing Ligyrtus, a mountain of Arcadia, on his march to the siege of Psophis, by reason of *deep snow* which covered the mountain. But that the cold was not great, we have evidence in the same book, as the army, a few days afterwards, passed over the river Erymanth, on a bridge, for it was not fordable.*....*Polyb. Megalop. Hist. lib.* iv.

In an account of the invasion of Sparta by Epimanondas, in the Travels of Anacharsis, the author remarks that the Theban general was making dispositions to pass the Eurotas, then swelled by the melting of snow, chap. 1. where is cited as authority....*Plutarch's Life of Agesilaus.*

From these passages, we conclude that snow fell in winter in Lacedemon, especially on the mountains, but was soon dissolved; and hence Polybius observes of a river on the west of Psophis, that it was seldom fordable in winter. But I find no evidence in history that frost of any severity was ever experienced in Lacedemon or Attica. On the other hand, it is related from Plutarch, that when Epimanondas was in Arcadia with an army, in winter, he was invited by deputies from a neighboring city to take up his quarters in the city; but he declined; assigning as a reason that if the Lacedemonians should see him and his men by the fire, they would take them to be ordinary men. He therefore chose to continue in camp, notwithstanding the rigor of the season, and continue their wrestling matches and military exercises....*Anarch. chap.* v. This anecdote indicates cool uncomfortable weather in that country in winter, but not severe cold, like that which freezes large rivers in America.

The author of Anacharsis relates from Columella, that the winter, in every part of Beotia, is very cold, and at Thebes almost insupportable; and that snow, wind and

* Strabo, lib. viii. informs us that Arcadia is a mountainous region; some of the mountains being fifteen stadiums in altitude.

want of wood, render that part of Greece an unpleasing residence in winter....*See ch.* xxxiv. With what caution we ought to receive such general accounts of climate, may be understood from the fact, that in Thessaly, far north of Beotia, and in a mountainous country, vines and olives came to perfection, according to the testimony of the same writer, in the same chapter. Cold and heat are comparative; and the degrees of them are not to be known from general assertions. Homer speaks of the wild fig-tree before the walls of Troy, a degree and a half of latitude north of Beotia....*Iliad, B.* 6. *v.* 433. And other ancient authors speak of the fig-tree, vines and olives growing in Macedonia, two degrees still further north....*Anarch. ch.* lxv. Pliny informs us that figs were produced at Mount Ida, near the site of Troy.... *Nat. Hist. lib.* 15. *ca.* xviii. Theophrast informs us that figs grew in great abundance in Pontus, on the south shore of the Euxine....*Hist. Plant. lib.* iv. 6. And Xenophon found, on his retreat with the ten thousand, figs and vines in abundance at Calpe, on the same shore, about 870 stadiums from Byzantium....*See his account, b.* vi. Pliny, in the book just cited, gives an account of a method of raising figs in Mœsia, the modern Bulgaria, in the 44th degree of north latitude, which was effected by covering small trees in winter with compost. These facts, and numberless others, which I have found in authors, furnish the most accurate test of the real state of the climate in Greece, Asia Minor, and the neighboring countries.

Joseph, in the fifth book of his Antiquities, ch. v. relates that in the battle between the Canaanites and the Israelites, under Barak and Deborah, the Canaanites were exceedingly annoyed by a storm of rain and *hail*, which blew in their faces, and rendered their bows and slings almost useless; while the cold benumbed their fingers, so that they could not use their swords. This fact would seem to confirm the common opinion that, anciently, Palestine was far colder than at present. But we must not be misled by single facts. In the very next chapter, the historian, in relating the sufferings of his countrymen, from the Midianites, informs us that their enemies invaded the country in time of harvest, and carried away or destroyed their corn for three years in succession: but permitted the Israelites to *plow their land in winter*, that they might furnish fruits of the earth for their plunderers. The latter fact entirely overthrows the opinion that anciently the winters were more rigorous than at present; for we see that it was customary to prepare the land for seed in winter, as it is at this day. A storm of hail or snow might happen occasionally in winter, as it does now in South-Carolina and Georgia, but the frost of ordinary years was not sufficient to impede the agricultural operations of winter.

Appian relates that at the siege of Numantia in Spain, many Roman soldiers perished by cold and frequent hail storms, about 145 years before the christian era. But Numantia was situated in the center and mountainous part of Spain, near the source of the Duro, where the laws of nature require us to suppose a considerable degree of cold in winter. Yet an anecdote related by Quintilian, book 6, shows that in Tarracona, the country where Barcelona is now situated, the climate must have been as mild as at present. The people of Tarracona informed Augustus, that a palm tree was growing from his altar. "From that I can judge," replied the Prince, "how often you use fire upon it." This story implies that palm trees grew in the north of Spain, and in the very latitude of Numantia, on the eastern coast, which is washed by the Mediterranean.

In the first chapter of the second book of Maccabees, the Jews of Jerusalem recommend to their brethren in Egypt to keep the feast of tabernacles in the month Casleu, which answers to a part of November and December. This circumstance among others led Prideaux to pronounce the epistles of the Jews in this chapter to be spurious; for, says that learned author, the Jews could not, in the middle of winter, make such booths, as in the feast of tabernacles; they could neither find green boughs enough, nor could they lie abroad in such booths ....*Connec. Part* ii. *b.* 3. This argument is undoubtedly founded on mistake; for in a country where the plowing and sowing of land was constantly carried on in winter, and where the palm tree flourished in perfection, ordinary winters would not render the temporary lodging in booths very uncomfortable; nor could such a country be necessarily destitute of green boughs. Let it be added also, that in the second chapter of the Song of Solomon, we find the winter was a season of *rain*, and not of snow. "The winter is past; the rain is over and gone."

In opposition to Prideaux's opinion, and to the general hypothesis of the rigorous winters of antiquity, it may be remarked that in Greece, six degrees of latitude north of Judea, the theaters were not covered, but plays were acted in the open air....*See Anarch. ch.* lxx. *where Vitruvius, lib.* v. *cap.* 9, *is cited as an authority.* The Roman theaters and amphitheaters were also without roofs. Indeed for centuries after theatrical representations were introduced at Rome, the theaters were temporary structures of wood, without seats, the spectators standing during the exhibition....*Tacit. An.* xiv. 20. It is evident also from a passage in Quintilian, lib. 10. ch. iii. that the courts of justice were held in apartments without roofs; and so was the Areopagus in Athens....*Acts* xvii.

Authors inform us that in the later ages of refinement at Athens, the stage, and a part of the theater occupied by the ladies, were covered; but the spectators in general had no covering but their clothes. Plays were indeed acted in Greece in the day time; but as they were acted at all seasons of the year, the open theaters forbid us to suppose the winters more rigorous and tempestuous formerly than in modern days.

The thin dress of the Romans and Greeks is another proof of the mildness of their climate. The Romans wore no garments answering to the modern breeches and stockings; their principal garments being the *Tunica*, or close coat worn at home, and the *Toga*, or loose gown without sleeves, worn in public; to which may be added the Trabea, Paludamentum, Chlamys and Læna, robes worn by men of distinction and military officers....*Kennet. Antiq. Rom.* ii. 5. 7. Hence the close garments which invested the lower limbs of the Celtic and Teutonic nations, were objects of notice among the Romans who travelled north of Italy. Ovid, among the curiosities of Thrace, the place of his exile, describes the skins and close *breeches* of the inhabitants.

"Pellibus et sutis arcent malè frigora bracchis"....*De Trist. lib.*iii. 10.*

And it is perfectly well known that this customary dress of the Gauls, gave rise to a distinctive appellation of the south-western part of their country, which was called by the Romans *Gallia braccata.* The customary light dress of the Romans, which continued down to the ages of wealth and luxury, and therefore cannot be supposed to have been the effect of necessity, as it is among savage nations, furnishes strong evidence of the uniform mild temperature of ordinary winters in Italy.

Velleius Paterculus, lib. xi. ca. 105. mentions that the Roman troops, in the reign of Tiberius, kept their summer quarters, till December, in Germany, at the head of the Lippe, near the modern Paderborn, in Westphalia, and in the 52d degree of north latitude.—This was favorable to the operations of the campaign, as the author remarks; and indicates a climate as temperate as in modern days. Yet at that time, the historian informs us, the Alps were almost impassable by reason of snow.

Xenophon, in his Anabasis or Expedition of Cyrus, has described the sufferings of the troops in their retreat through Armenia, four centuries before the christian era, from great quantities of snow and severe frost. The snow in one place, he says, was a fathom in depth: and many horses and slaves, and some soldiers died—others lost their limbs by the frost....*Book* 4. Three days before the snow fell, the troops forded the Euphrates, with the water to their navel.

The troops of Lucullus experienced inconveniences from the same cause, in the same country, during the war against Mithridates. Plutarch informs us, in his life of that General, that before the winter equinox, the weather grew tempestuous and great quantities of snow fell; that the soldiers, marching in the woods, were wet by snow which fell from the trees—but at the same time,

* This line is repeated, lib. 5. vii. with the change of *sutis* to *laxis*, loose breeches, or trowsers.

he says, they were obliged to encamp at night in *wet* and *miry* places—so that it was not cold enough to freeze water. But we must not conclude from these facts that the climate of that country is altered; for Chardin and Tournefort, in the 17th and 18th centuries, found the temperature of the winter precisely as described by Xenophon and Plutarch. Chardin informs us, that when he passed Caucasus, the snow was, in some places, ten feet deep—his guides wore snow shoes, and in some places, shovelled for him a path. At Tefflis, on the river Kur, it snowed all day, when he first arrived; and he repeatedly mentions that the mountains of Armenia and Georgia, which are in the 40th, 41st and 42d degrees of north latitude, are never destitute of snow....*See pages* 166, 171, 241, 242, 247, 413. *Lond. fol.* 1686.

Tournefort arrived at Erzeron, at the foot of a mountain near the head of the Euphrates, in the 40th degree of latitude, on the 15th of June, and found the neighboring hills covered with snow. The nights were so cold that his fingers were too numb to write, until an hour after sunrise. The wheat harvest was in September..... *See his Travels, vol.* iii. *p.* 75, 81, 82, 94, 102, 107, *&c. Lond. 8vo.* 1741.

At Erivan, in the 41st degree of latitude, says Chardin, the winter lasts long, so that it sometimes snows in April; the country produces wine in abundance, but the people are obliged to cover the vines in winter....*p.* 247. From these authorities we may infer that the winter temperature of Armenia and Georgia has not abated within 2000 years.*

It has been already remarked that snow formerly fell occasionally in Greece, even in the Peloponnese; and the most credible testimonies agree that mount Ida, in

* Herodotus, book i. relates that at Babylon, which was in a mild climate, far south of Armenia, the ancient inhabitants did not cultivate the vine, olive and fig; but he insinuates that this neglect was owing to the peculiar fitness of the soil for corn. That it could not be on account of the climate, is certain; for the same author relates that the palm tree was cultivated with success; and caprification was then practiced as in modern times. Herodotus also says, that palm wine was an article of merchandize, transported from Armenia down the Euphrates, in boats made of willows covered with skins.

Crete, was always clothed with snow....*Plin. Nat. Hist. lib.* 16. *ca.* 33. *Theophrast. Hist. Plant. lib.* 4. *ca.* 1. Tournefort visited this isle in his voyage to the Levant, and testifies that the inhabitants of Canea fetch their snow, in summer, from the neighboring mountains; and he confirms the assertion of Theophrast and Pliny, that the cyprus grows there among the snow. At the foot of these mountains grow figs, olives and other delicate fruits, as they did in the earliest ages.—*Tournefort, Let.* 1.

In Milo, says the same traveller, *Let.* 4. it never freezes and *very rarely snows;* when it does, the snow melts in a quarter of an hour; the cold is not prejudicial to the olive trees, as it is in Provence and Languedoc, where the contexture of the bark is torn by the dilatation of the water which freezes in the pores.

When Tournefort visited Samos in February, he found the cold severe on the mountains, and on the 23d of the month, some snow and a great deal of hail....*Vol.* ii. *let.* 3.

On mount Olympus, in Asia Minor, says the same author, nothing is to be seen but old snow in a very great quantity. This was in November. He also says, that a river which runs by Tocat, does much injury when swelled by rain, or the melting of snow....*Letter* 9.

The river Meles, says Chandler in his travels, ch. xx, which washes Smyrna, swells into a torrent, after heavy rains on the mountains, or the melting of snow. The houses in Smyrna, except those erected by Europeans, seldom have chimneys; but in cold weather, a pan of charcoals, under a table covered with a carpet, serves to warm the family.—The same author mentions snow upon the summits of mountains, as he passed from Smyrna to Ephesus, Miletus, and Laodicea, as late as March and April....*See his Travels, 4to. Oxford,* 1775. *pages* 71, 80, 105, 164, 221, 224.

The same author, vol. 2. p. 79. speaks of snow on the mountains of Attica. The Illissus, he says, in summer is quite dry; and while he resided at Athens, he several times visited the river, after snow had fallen on the mountains, in hopes to see it fill its banks. He observes also that the Cephissus is a small stream, and absorbed before it reaches the sea, except after the melting of snow, or a heavy rain. In describing the dress of the modern Greeks, he mentions in addition to their ordinary garments, a long vest, which they hang on their shoulders, lined with wool or fur for cold weather.... *Vol.* 2. *p.* 110, 119.

This author further states that when the mountains in Attica are covered with snow, the woodcocks descend into the plain; and if the ground continues froze and the weather severe, they enter the gardens, and are so tame as sometimes to be taken by the hand....*p.* 127. *See also p.* 163. On his journey to Delphi, in the beginning of July, he found the summits of the mountains white with snow; and Parnassus is covered with perennial snow....*p.* 260, 270. This confirms the account which Homer gives of the climate of Dodona, which he calls very cold....*Iliad.* 11. *v.* 750.

All these authorities prove beyond a question that the climate of Greece and Asia Minor, in modern days, corresponds well with the representations given of it in ancient history.*

There is a passage in Pliny, *Nat. Hist. lib.* ii. 50, which, after assigning reasons why there is no thunder in cold countries in winter,† expressly declares that the climate of Italy is always mild. "Mobilior aer mitiore hyeme, et æstate nimbosa, semper quodam modo vernat vel autumnat,"—always exhibiting the verdure of spring or the mildness of autumn. He says, chapter 47th of the same book, that the swallows appear by the 24th of February. This account corresponds with what has been

* There is a passage of Herodotus, in Euterpe, which indicates that snow sometimes fell in his native country, Halicarnassus; for he asserts that a fall of snow must be followed, in five days, by rain. This remark represents the climate of that country nearly as it is at present.

† Herodotus, in Melpomene, mentions the same fact, in describing Scythia. This is known to be correct at this day. In northern climates, there is no thunder in winter—but in Italy and Greece, thunder is known only in winter or spring. This fact, corresponding with the statements of Herodotus and Pliny, proves the climates of Italy and Greece to be the same as in their days.

before remarked, respecting the germination of plants in the same month.

There is a passage in Joseph (Jewish War. b. 3. ch. 10,) which describes the climate near the lake of Gennesareth, as remarkably mild and pleasant; and after mentioning its fruitfulness in palm-trees, olives and figs, it is said that grapes and figs are supplied from the trees for ten months in the year. How incompatible is this description with the supposed rigor of the ancient winters in Judea!

Tacitus informs us, *Hist. lib.* 3. 59. that Vespasian's army, in passing the Appenine to quell a revolt in winter, suffered severe distresses from cold and snow. But we must recollect that the French army, but a few years past, suffered equally from the same causes, in the same country, on their march through the Neapolitan territories.

Pelloutier, in his history of the Celts, *book* i. *ch.* 12, asserts that in the time of the first Roman Emperors, "On ne recueilloit encore dans les Gaules, ni vin, ni huile, ni d'autres fruits, et cela à cause de la rigueur du climat, et du froid excessif qui y regnoit." He admits indeed that in Germany were some cultivated fields, but not one fruit tree, as such could not sustain the rigor of the cold. The boldness and positiveness of this writer, led me to recur to his authorities and examine them with care.

Strabo, a most diligent investigator, and accurate geographer, in the very passage cited by Pelloutier, overthrows the assertion of the latter author. "Narbonensian Gaul," says Strabo, "produces the same fruits as Italy. Proceeding to the north and the Cevennes, the country produces the same fruits, the fig and olive only excepted."—*Book* iv. § 2. This account corresponds with that of Pliny, as I have in my former dissertation stated at large; where it is proved that figs and olives grew, in the times of the first Emperors, in the province of Narbonne, which comprehended the more modern Provence and Dauphinè, and that north of that region they will not now thrive, nor are they cultivated. But all parts of Gaul, says Strabo, will produce the fruits which grow in Italy, except the fig and the olive. Italy, it is agreed, produced figs, olives, and various kinds of wine. "Latium," says Strabo, *lib.* 5. "enjoys a mild climate and produces all kinds of fruits [παμφορος] excepting the marshy lands on the sea coast, and some mountainous tracts; but even these produce abundant pasturage, many kinds of fruits, and even one excellent kind of wine."

Strabo, in his second book, makes very correct and judicious remarks on climate; stating that mountainous regions are colder than valleys and low plains. He mentions Bagadania, an elevated plain between mount Taurus and Argea, which produced scarcely any fruit trees, altho situated 3000 stadiums south of the Euxine, where, at Sinope, the country produced olives. This circumstance has not been sufficiently considered in estimating the descriptions of climates and seasons, in ancient authors. Strabo then observes, that upon the Boristhenes, now the Neiper, and in that part of Celtica which is *contiguous to the ocean*, the vine either will not grow or not produce fruit. Celtica was that part of Gaul which is comprehended between the Garonne and the Seine.... *Cesar. Com. lib.* 1. Now let it be remarked, that the vine is cultivated at this day, in the *maritime* part of France, to a very little distance north of the Loire, in the 48th degree of latitude, altho, in the interior country, it is cultivated with success to the 50th degree. Strabo's assertion therefore, with regard to Gaul, is almost literally verified by modern facts.*

Strabo then mentions the climate on the north of the Euxine, and the fact that, at the mouth of the Palus Maeotis, a general of Mithridates, with a body of horse, defeated the barbarians upon the ice, on the very spot, where in summer he defeated them in a naval engagement.

A fact of this sort is of no effect in settling the question respecting a change of climate, because we know

* See Young's Tour in France, vol. ii. ch. 3. and his map of the climate. Pausanias informs us that olives grew in Tithorea on mount Parnassus, which is in the 39th degree of latitude.....*Phocics. ch.* 32.

not whether the water in the strait of the sea of Azof annually congeals in winter into firm and solid ice, or whether the fact mentioned, was owing to an unusual occurrence, and related for that very reason. The circumstances naturally lead us to conclude that the ice in that year was stronger than usual, and that the winter was uncommonly severe.

Strabo then proceeds to state from Eratosthenes, the story of a brazen cup or vessel which had been burst by the freezing of water, and as an evidence of the fact, was preserved in the temple of Esculapius at Panticape, a town on the Cimmerian Bosphorus. He cites the inscription on the vessel of which the following is a translation. "If any man disbelieves what events have taken place among us, let him view this vessel and learn the truth—This vessel has been deposited here by Stratius, the priest, not as a gift to the gods, but as an evidence of a *very rigorous winter*." [χειμωνος μεγαλȣ.] The translator has rendered these words by *immensi frigoris*, which would describe severe cold in general. But such mistakes of the meaning of original writers are the sources of many false theories. The Greek χειμων will not justify this translation—It signifies *winter*, and in connection with *great*, evidently denotes, in this place, an *unusual winter*. Strabo indeed speaks of the freezing of the Cimmerian Bosphorus, in general terms, and of large fishs' being dug out of ice, where they had been caught in nets; and if this should on inquiry be found to be the fact now, we ought not to be surprised, as that strait is in the latitude of Quebec. Severe as the cold was, the Greeks opened a communication with the nations on the north of the Euxine, and built cities on the coast, among which were Panticape, on the strait, and *Olbia*, on the Boristhenes near the mouth of the Hypanis, or Bog. From what circumstance, this town received its name, I know not; but it signifies *happy* or the pleasant residence.....*Strabo, lib.* 7. *D'Anville Anc. Geog*. ix.

That Germany would not produce fruit trees, at the christian era, must not be believed; for vines were cultivated in Gaul, as far north as the territory of the Sequani, since called Burgundy and Frenche Compté. And Strabo informs us, that a celebrated prince of the Getæ, after subduing some nations in Thrace and Pannonia, persuaded them to cut up their *vines* and live *without wine*....*Lib.* 7. Yet Thrace as well as Germany is represented by the Roman and Greek writers, as oppressed with intolerable cold.

That there is much inaccuracy and some exaggeration in the descriptions which ancient writers have given of the winters north of the Alps and the Danube, may be clearly proved by a comparison of these accounts one with another. Tacitus, a writer of great credit, says of Germany, "Terra, etsi aliquanto specie differt, in universum tamen aut silvis horrida, aut paludibus fœda."....*De Mor Germ.* 5. The country is *all* deformed with woods and morasses. He observes that the soil is "satis ferax," sufficiently fruitful; but "frugiferarum arborum impatiens," not fitted to produce fruit-bearing trees; yet in a subsequent section, he informs us that the inhabitants eat "agrestia poma," wild or uncultivated apples; and those who lived near the Rhine, purchased wine—"Proximi ripæ et vinum mercantur." If neither Gaul nor Germany produced wine, where did the dwellers on the Rhine procure it?

Tacitus informs us further, that the Germans cultivated land, chiefly indeed by their servants, old men and women, as the men preferred war to labor. But they raised barley and other grain, not only for food, but for drink; for their chief liquor was a species of beer or ale, made from fermented barley and other corn. The lands were cultivated by slaves, who lived upon the land, like tenants, and paid to their masters a certain part of the produce. How incompatible are these facts with the assertion that the country was all covered with forest and morasses! Nor is this account more compatible with the state of pasturage in Germany, which, as all authors agree, supported vast herds of cattle.

But to close all, Tacitus himself assigns reasons why Germany was not well cultivated, without resorting to the asperity of its climate. After stating that the inhabitants parcelled out the fields among themselves, *accord-*

ing to the rank of each individual, [a fact in which we see the germ of the feudal system] and that the fields lay fallow every other year, the author says, "nec enim cum ubertate et amplitudine soli labore contendunt, ut pomaria conserant, et prata separent, et hortos rigent sola terræ seges imperatur."—So that after charging the defect of fruit trees in Germany to the severity of the winters, this grave writer informs us that it is to be ascribed to the *want of labor*. The people were warlike, impatient of labor, and not having known the pleasures of luxury, they wanted only corn for subsistence. Here we have the whole truth.

But the passages in Ovid and Virgil, describing a Thracian winter, which I have before mentioned, require some consideration....*Ovid de Tristibus, lib.* 3. *El.* 10. *Virgil. Georg. lib.* 3. *v.* 355.

Ovid employs the whole of the 10th Elegy of his third book in describing the phenomena of a Scythian winter, as it appeared at Tomos, a town built by the Greeks, near the south bank of the Danube, on the Euxine. The passage is too long to be here transcribed; but the principal phenomena of the winter were, violent storms, deep snow, and frost so severe as to freeze wine in jars, and the Danube covered with solid ice, sufficient to sustain horses and cattle with waggons, or whatever might be the vehicles called *plaustra*. Virgil's description corresponds in general with Ovid's; and he adds that snow accumulated to the depth of seven [ulnos] cubits, about ten or eleven feet—that cattle perished with cold—and that deer, plunged in snow almost to the top of their horns, were killed with knives, not being able to escape.

On these descriptions, I would offer the following observations:

1. Some allowance must be made for the license of the poet. Exaggeration is admitted into verse for the purpose of exhibiting strong images to the mind; and when Virgil speaks of snow ten feet deep, it will be obvious that he must have had in view snow-drifts which often accumulate to that highth, in the middle latitudes of the earth, taking, as a poet naturally would, the most remarkable phenomenon as the subject of representa-

tion; or he must have intended to describe the piles of everlasting snow upon the mountains; or he must have described some very extraordinary snows in severe winters. Every man will at once perceive that no country would be habitable in winter, where the common depth of the snow should be ten feet upon a level. That the country of Thrace and Scythia, to the Tanais or Don, was inhabited by numerous tribes of men, who subsisted by hunting and pasturage, from the earliest times, is an indisputable fact; and the numerous flocks of cattle and horses kept by the Nomadic Scythians, long before the time of Virgil, is a powerful argument against the supposed severity of the winters in their climate; for they did not cultivate the earth to any considerable degree; and if the winters were of six or eight months duration, as ancient authors pretend, how was it possible for them to subsist their cattle?

The "semper hyems, semper spirantes frigora cauri" of Virgil, must therefore be intended for Mount Rhodope, which is still covered with snow the whole year, or it must be a poetical fiction.* In the same light must we view the representation Virgil gives of the mode of spending the winter in Scythia; where, he says, the inhabitants dug caves for their residence, and warmed them by rolling *whole oaks and elms* upon their fires. This and other parts of the description are evidently too high colored. But most of the phenomena described by Virgil and Ovid, are such as we observe in the northern parts of this country; and such as occur in New-England, in winters of uncommon severity. If these were the ordinary phenomena of the cold in the countries along the Danube, now comprehended in Bulgaria, Wallachia, Bessarabia and Hungary; and if such phenomena do not now occur in ordinary years, there must have been a change of climate. With regard to modern winters in

* Virgil begins his description with the country about Rhodope, but a part of it must refer to the polar regions, or be a poetical fiction. Indeed the ancients had but little knowledge of the country north of the Danube, and confounded various climates in general descriptions. Herodotus however informs us, that the land along the Boristhenes was very fruitful in corn. He also speaks of the *plowing* Scythians....*See his Melpomene*, 52, 53.

that region, I have very little information. It is certain, however, that the Danube still freezes; altho my information does not enable me to say to what degree.

2. My second observation is, that the freezing of wine does not imply great severity of cold. Madeira congeals at 10° above cypher by Farenheit; and the lighter wines of Italy, Greece and Asia Minor, would undoubtedly freeze with a less degree of cold.

3. The accounts which historians give, as well as Ovid, of the irruptions of the barbarians into Thrace and Italy, in winter, by means of a bridge of ice, and the drawing of their *plaustra* upon the ice and snow, demonstrate that the snow was not of a depth beyond what is usual in New-England.

4. But we have, in Ovid's 12th elegy, more certain data to judge of the winters in Thrace. The poet, after indulging his fancy in describing the gloomy scenes of a Thracian winter, assumes a more cheerful air, and paints the beauties of the following spring. "Frigora jam zephyri minuunt," says Ovid, at the equinox. He then observes that the year past, the winter of Maeotis seemed longer than former winters. Whether he means longer than former winters in the same country, or whether, that being the first winter after his exile, the winter appeared longer to him than it had done in Italy, is not quite certain. If the former, the winter was unusually long, and probably unusually cold; and therefore not to be considered as a standard of the general temperature of ancient winters. If we are to understand the passage in the latter sense, the remark is rather trifling; for who could question that a winter in Thrace, would not appear longer to any man than a winter in Italy; and especially to a wretched exile, forced from his family, his country, and all his former enjoyments?

But we must not pass unobserved the facts mentioned by the poet at this time—the spring equinox.

Now the merry youth, says Ovid, gather violets, which the uncultivated earth produces; the meads are decorated with blossoms of various hue, and the woods resound with the melody of birds. To this he adds that the swallows appeared and built nests *sub trabibus*. If swallows appeared in Thrace, immediately after the equinox, the spring must then have been three or four weeks earlier than in New-England; for they do not appear here till late in April. The same fact is indicated by the blossoming of plants. These representations of the poet appear to be important in settling this question.

Several passages in the most respectable ancient authors, leave us no room to question, that not only the Cimmerian Bosphorus, the Don and Boristhenes, but that the Danube and Rhine were, in winter, covered with ice sufficient to bear the heaviest loads, and that armies often crossed them on the ice. These facts are diriectly asserted in the following passages....*Herodotus in Melpomene*, 28—*Xiphilin's Epit. of Dion. Cassius, M. Ant.*—*Herodian, lib.* 6—*Pausanias, lib.* 8, *cap.* xxviii.—*Jornandes De Rebus Geticis.* 55—*Ammianus Marcellinus, lib.* 31. *ca.* x.

Herodotus speaks of the Euxine Sea and the Cimmerian Bosphorus. Ovid asserts the like fact of the Danube, and probably intended that part of the river which is near its mouth. Pausanias mentions the Hypanis, now the Bog, the Boristhenes, now the Neiper, the Ister, or Danube and the Rhine. The other authors speak of the Danube and Rhine near their sources in the south of Germany and Helvetia. These writers represent the freezing of these rivers as common events—at least they make no discrimination between winters; and Herodian, in the passage cited, says of the Rhine and Danube, φυσις μεν δη των ποταμων αυτη—*This is the nature of those rivers.* He speaks of these rivers as they were in the country, which now comprehends the dominions of Austria, Bavaria and Swabia; for it was in those countries, where the barbarians usually crossed the rivers to invade the Roman empire.

The ice however was not always sufficiently strong to sustain armies; for about the year before Christ 175, a body of Bastarnians, returning from an irruption into Dardania, attempted to cross the Danube on the ice and were almost all drowned....*Baker's Livy, book* 41.

How frequently the Rhine and Danube, in the same countries, are covered with ice of similar strength in modern days, I know not—for unfortunately modern travellers furnish little information on the subject. Pelloutier, who has cited most of the authorities of antiquity on this subject, says, the freezing of the Rhine, the Danube, the Elbe, the Weser, and the Oder, in such a manner as to sustain armies, is now an extraordinary event, which happens scarcely once in ten years—"La chose arrivera à peine une fois dans dix ans."....*Hist. des Celts. lib.* 1. *ch.* 12. But Cluver says, "Danubius in Germania glaciem fert."....*Lib.* i. 12. The Danube in Germany bears or is covered with ice.

Let it be remarked that at the battle of Austerlitz, Dec. 2, the Russian troops were said to have crossed a lake on the ice. Bonaparte, in his account of the action, represented that most of them fell through the ice and were drowned; but by the official Russian account, it appears that the troops passed over in safety.

Let it be further remarked that Cesar, in his history of his seven campaigns in Gaul, during which his troops were often disturbed in winter by insurrections of the inhabitants, which obliged them to leave their winter quarters, and march great distances, tho he often mentions the extreme hardships suffered by his troops in these marches, and particularly the difficulty of transporting baggage, has not mentioned the word *snow* [nivis] in a single instance, if my memory does not deceive me, except when speaking of the march over the Cevennes; and on these mountains, snow falls in modern days to a depth equal to that mentioned by Cesar....*See Pinkerton Geog. France.*

But whatever may be the fact with respect to the climate of Germany, there is positive evidence that the rivers in Greece and Italy did not freeze to any considerable degree at the christian era. Pausanias, after mentioning the freezing of the Danube and other northern rivers, describes the water of the rivers in Arcadia as fit for bathing even in winter....*Lib.* viii. 28. Herodian, speaking of the discontents (on account of the climate,) which prevailed among the troops of Commodus, who performed service on the Danube, and who complained that they had frozen water to drink, speaks of the rivers of Italy, by way of contrast, as cool flowing streams.... *Lib.* 1. But our best authority is Ovid, who, after relating the fact that the "Sarmatic cattle draw carriages upon the Danube," declares, "Vix equidem credar"—"I shall hardly be believed;" yet he adds, "when a witness has no motive to misrepresent facts, credit is due to his testimony." Now if the freezing of rivers to such a degree as to sustain carriages and cattle appeared incredible to the inhabitants of Italy, to one of whom Ovid was writing, it amounts to full proof that the Italians had never seen such a phenomenon, in their own country. This disproves utterly the degree of cold in ancient Italy, which modern writers have supposed, and confirms what I have before suggested, that the instance of the freezing of the Tiber mentioned by Livy, was an extraordinary event, which excited general surprise, like our winter of 1780. Indeed, all the descriptions of the rigorous winters in Thrace, Germany and Gaul, being given by historians and poets who were accustomed to the mild climates of Greece and Italy, wear the features of exaggeration, which must have been impressed upon them by the astonishment of the writers. These facts seem to decide the question, that the winters in Greece and Italy were, 2000 years ago, as mild as they are in this age—and that if any change has ever taken place in those countries, it must have been anterior to the age of the writers mentioned. Indeed Columella, De Re Rustica, lib. i. 61. mentions the opinion of an author, that such a change had taken place—and cites as a proof of it, the fact that vines and olives would thrive in countries where the cold, in preceding ages, had prevented their cultivation. I am satisfied, however, that although the *draining* and *drying* of land is often necessary to the cultivation of particular fruits, yet most of what has been charged to *cold*, ought to be ascribed to the *indolence* or *military spirit* of savage men, who preferred war and hunting to agriculture.

In addition to what I have said, on the subject of the winters in America, I have a few remarks to cite from two writers of undoubted credit.

John Megapolensis, a Dutch clergyman, who resided at Albany, and wrote an account of the Mohawks, in 1644, a translation of which is in Hazard's Collection, vol. i. 517, says, of the climate, "the summers are pretty hot, and the winters very cold. The summer continues till All Saints' Day, (Nov. 1,) but then the winter sets in, in the same manner as it commonly does in December, and freezes so much in one night that the ice will bear a man. The freezing commonly continues *three months*—sometimes there comes a warm and pleasant day, yet the thaw does not continue; but it freezes again till March, and then commonly the river begins to open, seldom in February." According to this account, the winters have not moderated; for the Hudson, at Albany, usually freezes early in December, and continues closed till March. A common winter is of three months duration.

Professor Kalm, who came to America in 1748, was very particular in his inquiries on this subject; and to the best information he could obtain, he added his own observations. He relates, vol. i. p. 21. Lond. 1772. that at Newcastle, the Delaware seldom froze in winter so as to obstruct navigation; but at Philadelphia, that river was, almost every winter, covered with ice, so as to interrupt navigation for some weeks together. In page 36, he says, the climate of Philadelphia was then temperate; the winter was not over severe, and its duration short—September and October were like August in Sweden, and the first days in February frequently as pleasant as the end of April and beginning of May in the middle of Sweden.

In page 38 he says, the only disadvantage which the trade of Philadelphia suffers, is, the freezing of the river almost every winter for a month or more. In page 83 he states, that the winters he spent in the country were none of the coldest, but common ones, and that during his stay, the Delaware was not covered with ice strong enough to bear a carriage. In the next page, he adds, that the winters, tho severe, did not continue above two months, and at Philadelphia, sometimes less. Cherries were ripe about the 25th of May—(probably old style.)

In page 197, the author, speaking of New-York, states that the *harbor is good, and never froze except in extraordinary cold weather;* but he says, page 208, the winters at New-York are much more severe than in Pennsylvania. He says afterwards, that the ice *stands on the Hudson several months*, by which he must mean the ice on that river in the interior country. January 21, 1749, people walked over the Delaware at Philadelphia on the ice; but no one ventured to ride over on horseback. But in page 362, the author informs us, that the river was covered with ice soon after new year, and the ice became so strong that people rode over on horseback—the ice continued to the 8th of February, when the river was cleared.

The old men, of whom Kalm made inquiries respecting a change in the seasons, all agreed in the fact, that when the country was first settled, the weather was more uniform than it was in their time. Most of them were of opinion, that more snow fell when they were young; that the winters began earlier; and that the springs were also earlier. It was a saying among the old Swedes, that they had always grass at Easter, whether early or late.

Mr. Norris, one of the first settlers of Philadelphia, and a merchant, related, that in his younger years, the Delaware was usually covered with ice by the middle of November, old style. One old Swede, who remembered the very severe winter of 1697-8, was of opinion, there had been little change in the winters—that there were as great storms and as cold winters in his old age as in his childhood.

Kalm, however, in his second volume, page 43, institutes a comparison between Old and New Sweden, as he terms the two countries, in which he mentions, among the disadvantages of New Sweden, or Delaware and Pennsylvania, that the nights are darker than in Old Sweden, where they are in part illuminated by snow and the lumen boreale. In this paragraph he says expressly, that the winters bring no permanent snow in Pennsylvania, to make the nights clear and travelling safe. The cold, he says, is often intense as in Old Sweden; but the snow which falls lies only a few days, and always goes off with a great deal of wet.

From a careful comparison of these facts, it appears that the weather, in modern winters, is more inconstant, than when the earth was covered with wood, at the first settlement of Europeans in the country; that the warm weather of autumn extends farther into the winter months, and the cold weather of winter and spring encroaches upon the summer; that the wind being more variable, snow is less permanent, and perhaps the same remark may be applicable to the ice of the rivers. These effects seem to result necessarily from the greater quantity of heat accumulated in the earth in summer, since the ground has been cleared of wood, and exposed to the rays of the sun; and to the greater depth of frost in the earth in winter, by the exposure of its uncovered surface to the cold atmosphere.

But we can hardly infer, from the facts that have yet been collected, that there is, in modern times, an actual diminution of the aggregate amount of cold in winter, on either continent.

No. II.

A DISSERTATION

ON THE PRODUCTION OF VAPOR;

In which it is attempted to explain some curious phenomena that attend its ascent.

BY ELIZUR WRIGHT, ESQ.

WATER has, till lately, been considered by philosophers as an uncompounded substance; and has accordingly been classed among the elements. Some of the phenomena of water, on this principle, have been of inexplicable solution. How it could come to pass, that so ponderous a body as water should be raised and sustained in the lighter air in the form of vapor, was long viewed as a mystery. The fruitful imagination of philosophers has, however, invented several hypotheses to account for this wonderful process of nature. It has been considered, that the gravity of bodies diminishes, cæteris paribus, in proportion as the cubes of their diameters, that is, as their solid content; but their resistance in a fluid, or their capacity of being supported by it, diminishes only as the squares of their diameters, that is, as their surfaces. Hence, since the gravity decreases in a higher ratio than the resistance, by diminishing the bulk of any heavy body, it may be made to swim in a fluid of any given rarity—for instance, water, or even air. Thus gold, and other heavy metals, when sufficiently comminuted, are observed to be suspended and swim in water; and if the difference between the solid content and the surface of the pieces is sufficiently increased, they may be sustained and made to float even in air.

Others have imagined, that vapor arises upon the principles of the capillary tube. They suppose that the particles of the atmosphere are so disposed as to form an indefinite number of tubular interstices, which act in the nature of a filter; and raise up, by the attraction of cohesion, the minute columns of water that compose clouds. They have compared this phenomenon to tallow that rises in the wicks of candles; and to tubes of sand or ashes, that will raise water to the height of several feet.

Others again have maintained, that vapor consists of bubbles of water, filled with rarefied air. These balloons of nature's workmanship, they conceive to ascend and sail along in the atmosphere, until by some accident they burst, and fall down in rain.

Each of these hypotheses are liable to objections, that cannot easily be removed; and appear to be insufficient to explain the phenomena.

Water has been found to be a compound substance, consisting of 85 parts of oxygen, and 15 parts of hydrogen. Its natural state is ice: by its combination with caloric, it is rendered fluid. Both by natural and artificial methods, water may be converted into air, and air into water. One of the nutritive principles of vegetables, and, as has been proved by experiment, the only one in some, is water. By the digestive power of the plant, the water that is absorbed by it, is decomposed. While the hydrogen, modified by the organic system peculiar to the plant, is retained to nourish and form a part of it; the oxygen transpires through the parenchymous part of the leaves, and forms vital air. Thus water is converted to air by a natural process. Vegetable fermentation, and animal putrefaction, produce hydrogen gas; and whenever it is extricated, it immediately combines with vital air, and generates water. But, from the circumstances under which hydrogen gas is produced, it can by no means be supposed to exist in so large quantities, as to generate the abundant vapor that exists. Large quantities of vapor daily ascend from the surface of rivers, ponds, lakes, and seas. Doct. Halley found, that in the summer season, there arises in vapor at a medium, daily, from every square foot of the surface of water half a pint, from every square mile 6914 tons, and from the Mediterranean sea 5,280,000,000 tons. This prodigious quantity of water is not changed into air. Nature affords no re-agent to decompose it. The conversion of water into air, and air into water, appears therefore not to be the *grand process of nature*, by which clouds are formed, and precipitated in rain. Though by the elimination of hydrogen gas, and its combination with pure air, a small quantity of vapor may be generated, we are to look somewhere else for the principal cause of the production of vapor.

To make water ascend in vapor, it seems necessary that some alteration in its texture should take place, that should render it so porous as to be specifically lighter than air. The alteration in the texture of bodies, is either under such circumstances, that their very constitution and nature is changed; in which case the attraction between the two bodies that unite, is strong, and they undergo a chymical combination; or the body, whose texture is altered, retains all its former properties; and pretty readily quits the substance it is united with. The attraction here is weak, and the process is termed by chymists *solution*. Solution is the disappearance of a solid in a liquid; or it is the change of a solid to a liquid, or to gas, without any alteration in the nature of the body dissolved. Water and fire are the great solvents or menstrua that nature furnishes. Corpuscular attraction, or what the chymists term affinity, is commonly said to take place between the integrant parts of bodies, when in contact only; but this is not strictly true. The constituent particles of bodies attract each other, when at a small distance; though that distance may be so small as to be insensible. The nearer the integrant parts of a body approach each other, the stronger will be their affinity. Every thing that tends to remove these integrant parts from each other, diminishes their affinity. Fire produces this effect upon most known bodies. And it not only diminishes their affinity, but being itself the lightest of all substances, and rendering the bodies it unites with more porous, it greatly inereases their levity. By the agency of fire, metals and ice are changed from their natural solid state to that of a liquid. The power of attraction is balanced by the opposite force of heat; the liquid state appears to be the point of the equilibrium between these two forces. By increasing the heat, most bodies are reduced to a state of gas. If we attend to the method that nature pursues, we shall find, that water is reduced to a state of vapor, and its texture is so altered as to become specifically lighter than air, by the agency of fire. Evaporation is, therefore, *a dissolution of water by fire.* The various substances that compose the universe are, therefore, subjected to a general law on the one hand, that tends to bring them together; and to a powerful agent on the other hand, which tends to remove them from each other. It is upon the respective energy of these two forces, that the consistence of all bodies depends. Whether heat or caloric is truly possessed of a repulsive principle, or whether it produces this effect only by its endeavor to combine with bodies, forcing the constituent particles to separate and recede from each other, and diminishing their force of aggregation, I shall not undertake to determine. A certain degree of affinity exists between most substances and caloric, but this degree in different substances is very various. It is therefore unequally dispersed in bodies, some absorbing and retaining it in greater, and some in less quantities. By contemplating the circumstances that attend its combination, we are led to conclude, that the component particles of bodies are surrounded with a caloric atmosphere or investiture, more or less extensive, according to their respective attraction. The parts of this atmosphere more distant from the particle thus invested, being but weakly attracted, will easily abandon it to restore an equilibrium of heat, and will then become free or thermometrical heat. But the parts that are nearer will be obstinately retained, and will not quit it; they have become chymically united with it; the heat will not be perceptible, and is called *latent heat.* Hence arises an easy solution of the difficulty some have started against the doctrine, that vapor is a solution of water by fire. They say, if it be allowed that fire rarefies water to such a degree as to render it specifically lighter than air, upon its ascending, the fire will abandon the water, to restore an equilibrium to the cooler air; and the water will return to its former gravity, and be precipitated; therefore, say they, water cannot be made to ascend in vapor upon this principle. But it must be considered, that a greater degree of affinity exists between water and caloric, than there does between air and caloric. Hence, though a part of the caloric may quit the particle of vapor to restore an equilibrium to the cooler air; yet a large portion of it being chymically united to the water, and, in respect to the air, becoming latent heat, a sufficient quantity will be retained to render it specifically lighter than air; therefore the particle of vapor will ascend.

A curious phenomenon attending the generation of vapor, is the production of cold. Whenever heat is increased and accumulated in one place, it is diminished, and withdrawn from the parts adjacent. Water, in passing from a solid or icy, to a liquid state, and from a liquid state to vapor, attracts the caloric from the contiguous substances. In combustion, the matter of heat is either extricated from its fixed state in the combustible substance, or, as it sometimes happens, it is attracted from the adjacent parts, which are consequently made cooler by the process. This principle has been applied to many useful and economical purposes. The Hungarians, when they travel through the hot deserts, dig a pit about two feet in depth, and bury their bottles of wine in it, covering them over again very close: then they burn straw or reeds over the place, and when the fire is out, they dig up their wine as cool as if it had been put into the coolest water. This fact is related in the Philos. Trans. of the Royal Society, No. 452. The inhabitants of China, India, Persia and Egypt, cool their liquors, used for drink, by evaporation. The water intended to be cooled is put into very porous vessels, and exposed to the sun, or to a current of warm air. In experiments made by Mr. Richmann in 1747, and inserted in the first volume of the Transactions of the Imperial Academy of Petersburg, a thermometer taken out of water and exposed to air of equal temperature, descended and remained below the height indicated by the water, until the bulb became dry, when it regained its former height. If the ball of a thermometer be wrapped in fine linen, and kept moist by sprinkling with ether, and the evaporation be facilitated by agitation in the air, the thermometer will descend to 0. Doct. Franklin has proved, that when the body perspires copiously, it is less heated than surrounding bodies; and that perspiration alway produces a certain degree of coldness. A surprizing degree of cold is produced by a solution of the crystallized salts. By using a saline mixture composed of eleven parts of dry pulverized Sal Ammoniac, ten parts of dry pulverized Nitre, sixteen parts of Glauber's Salts, and thirty-two parts of water, Mr. Walker has brought the thermometer to eight degrees below 0.

Another remarkable phenomenon attending the formation and ascent of vapor is, that the less the gravity of the air is, the more copiously is the vapor exhaled, and the greater its specific gravity. Chaptal observes, that evaporation is more speedy in proportion as the pressure of the air is less upon the surface of the fluid. The Abbè Rochon has applied this principle to distillation with singular advantage. It was found by the Abbè Mongez and Mr. Lamanow, that ether evaporated with prodigious facility upon the peak of Teneriffe. The same fact was observed by Mr. Saussure on the mountains of Switzerland. Whilst Doct. Halley was making his observations for a catalogue of the Southern stars, on the tops of the mountains in the island of St. Helena, such an uncommon quantity of vapor fell there in dew, as very much impeded his business, by covering his glasses over in six or seven minutes. In the account of an uncommon darkness on May 19th, 1780, contained in the first volume of the Memoirs of the American Academy of Arts and Sciences, there is mentioned a very curious observation on the ascent and situation of the vapor, which arose at that time, made by a gentleman at Pepperell. "About nine o'clock (says he) in the morning, after a shower, the vapors arose from the springs in the low lands in great abundance. I took notice of one large column, that ascended with great rapidity to a considerable height above the highest hills, and soon spread into a large cloud; then moved off a little to the Westward. A second cloud was formed in the same manner from the same springs, but did not ascend so high as the first: and a third was formed in the same places in less than a quarter of an hour after the second." One of the gentlemen who observed here, mentions a circumstance of somewhat a singular nature.—"Whilst the darkness continued, (says he) the clouds were in quick motion, interrupted, skirted one over another; so as apparently, and I suppose really, to form a considerable number of *strata*." As to the state of the atmosphere, Professor Williams, who gave the account, observes, "that its gravity was gradually decreasing the bigger part of the day." At Bradford, about thirty miles North of Cambridge, and nearly under the same meridian, the mercury in the Barometer stood at 6 o'clock, A. M. at 29 inches 82; at 10h. 20m. it was at 29 inches 68; and at 10h. 45m. it stood at 29 inches 67; at 12h. 15m. the mercury had fallen to 29 inches 65.—Farenheit's thermometer at Bradford, at 6 o'clock, A. M. was at 39°. At 12 oclock it stood at 51°. At Cambridge, at 12 o'clock, it was 51° 1-2.

These phenomena are the more noticeable, because they seem to take place contrary to the received law in hydrostatics, that *the tendency of a body to ascend or descend, in a fluid, is proportional to the difference between the specific gravity of the body, and that of the fluid.*—Therefore the denser a fluid is, the greater will be the facility with which a given body will ascend in it. We should be led to conclude from this, that the evaporation would be the most abundant, when the gravity of the atmosphere is the greatest. But the reverse of this happens. What cause can be assigned that can produce so unexpected an effect? If it should be said that when the gravity of the atmosphere is increased, it prevents the rise of vapor by its pressure upon the water, it might be replied, 1st. That the pressure is not such as to prevent even a small force from agitating the surface of the water, and if it is incompressible, and alway of the same density, no reason can be given, why an equal force should not dislodge as many aqueous corpuscles at one time as another. 2d. In water, a body will ascend with the same facility at the depth of an hundred feet, as at one; and if an increased pressure alters not the tendency of a body to ascend in water, it cannot in air.

The difference in the heights of the several strata of clouds observed by the gentleman at Pepperell, cannot easily be accounted for, on known principles. For as the gravity, and consequently the pressure of the atmosphere that morning was gradually decreasing, the vapors, which arose at the several times observed, as far as that cause had influence, would all gradually and equally expand; and would eventually ascend to an equal height. And as the heat was continually increasing, we should conclude that the column of vapor which arose last, would be more rarefied, and take the highest station, contrary to what was observed.

To account for these phenomena, it seems necessary to unfold some other principle; and from the several appearances that attend the formation and ascent of vapor, it is probably this; *that water is in a small degree compressible.* The contrary doctrine has been held by philosophers. But the experiments of Canton have proved, that the commonly received opinion is erroneous. He inclosed water in spherical glass vessels, from which a narrow neck proceeded, like that of a thermometer, the water was found to occupy a larger space when the pressure of the atmosphere was removed by the air-pump, and a less space when a greater pressure was added by the condenser. If water is compressible, it follows, that like the atmosphere, it has a variable density, decreasing more or less, according to the degree of compressibility, from the interior towards the exterior parts. In the atmosphere the density gradually decreases as we ascend from the earth. But in water the density is nearly uniform, till we come to the surface; where there appears to exist a stratum of water of a small insensible depth, so rare as to be nearly in a state of vapor.

The arguments and inductions from phenomena that conspire to prove the existence of this cause, are the following: 1st. Water is of an elastic compressible nature; therefore at the surface, where the attraction and pressure are the least, it will be more rare than at any assignable depth below, where the attraction and pressure are stronger, and consequently the water more dense. 2d. The affinity that exists between the particles of water among themselves, and also between the particles of water and caloric, is very strong; and vastly stronger than that between the particles of air, or that between air and caloric. If there were not a powerful attraction between the particles of water, when a strong heat is applied, the whole body of it would undergo a simultaneous expansion like air, and be dissipated in vapor at once. And if caloric did not possess a stronger attraction for water than for air, it would abandon the particles of vapor to unite with the air; hence the position is evident. 3d. The force of attraction between the particles of water is such, that when the whole cause is applied, the contrary force of heat is but just sufficient to balance it; this is apparent from the small degree in which water is capable of being compressed. 4th. Hence it will follow as a consequence, that water will soon attain to nearly a uniform density. For a particle is attracted not only by the one next to it, but by several adjacent ones. But at the surface, on account of the absence of the particles above, they will be less attracted, and consequently will range themselves at a greater distance; there will therefore be a stratum at the surface, much more rarefied than water in its common state. This rarefaction will be surprizingly increased by the investiture of caloric, which the particles of water are then in a situation to assume. At any sensible depth the affinity of aggregation is so strong, that it squeezes out and excludes the caloric; which will nevertheless, for the reasons before mentioned, be retained at the surface. This also accounts for the cooling process in evaporation. As fast as the matter of heat is thrown off in vapor, more is drawn from the neighboring parts, and propelled to the surface by the endeavor of the particles of water to come into union. And I suspect that like other fluids, having formed a current, it continues the same for a while after an equilibrium is restored. There are some phenomena of nature, that seem to indicate this; and cannot well be explained without the supposition. Unless it be admitted that there exists a stratum of rarefied water at the surface, it cannot well be conceived how any evaporation can take place. We cannot say how those small portions of water, that constitute particles of vapor, can be torn off and detached from the body of water; unless by the agency of heat the integrant parts are first separated to a greater distance from each other, and the affinity of aggregation thereby weakened. A small force, such as the agitation occasioned by the motion of the air, the action of the solar rays, or ebullition, will then be sufficient to throw off the water in minute particles; but if it should remain in its common state of density, the particles would be so strongly held down by attraction, as not to be dislodged by these causes. But the whole body of water is not thus rarefied; there must, therefore, exist a rarefied stratum at the surface, as a foundation for the formation of particles of vapor. The depth and rarity of this vaporific stratum, varies with the state of the atmosphere. When the air has a greater specific gravity, it so compresses as to render it less rare, and of less depth, than when the air possesses less gravity. This superficial stratum is of a variable density, increasing from the exterior toward the interior parts; this is evident, and results from the elasticity of the fluid. A particle of vapor is an assemblage of the exceedingly minute particles of water, rarefied by heat to such a degree as to be lighter than air, and increasing in density from the surface toward the central parts. When such a particle is detached from the body of water, it parts with a portion of its caloric, which before was retained by the attraction of the water. It hence arises that the gravity of vapor is, cœteris paribus, proportional to the magnitude of its particles. Since this rarefied stratum at the surface of water is necessary to the avulsion and detachment of the particles of vapor, the more it is rarefied; and the greater its depth, the more copious will be the exhalation. But this takes place, when the atmosphere has the greatest levity. Hence the phenomenon that evaporation is the most abundant, when the specific gravity of the atmosphere is the least. When the depth of the vaporific stratum is small, the lower particles will be strongly drawn down and held by corpuscular attraction, so that the causes which produce a separation will not be able to dislodge and generate particles of the larger size; but when it has a greater thickness, the attraction is so small as to be overcome at a greater depth, and particles of vapor of a larger bulk will be formed. The magnitude therefore of the particles, will be in proportion to the depth of the stratum. To account for the different heights that the columns of vapor, observed by the gentleman at Pepperell, assumed, it may be considered that when the first column arose, the air was dense, and the vaporific stratum consequently of small depth; the particles of vapor would therefore be small, and as their levity is in proportion to their smallness, they would mount up to a greater height. The gravity of the atmosphere was considerably diminished when the second column arose, and the consequent increase in the depth of the vaporific stratum admitted the formation of larger particles of vapor; but as the specific gravity of vapor is proportional to the magnitude of its particles, it must, on account of its gravity, take a lower station agreeable to observation.

No. III.

AN ACCOUNT

OF THE WHITTEN PLASTER.

SHARON, *7th Jan.* 1800.

SIR,

I HEREWITH submit to the examination of the Academy a sample of stone, called by our farmers *Whitten Plaster*, from the name of the discoverer, one Thomas Whitten, of Kent. Searching for iron ore upon his own farm, he, about two years since, came across an inexhaustible quarry of this stone. It is found to be an excellent manure; and though manifestly not a gypseous earth, yet it is not inferior to the Plaster of Paris in its effects upon indian corn, and in certain soils, upon clover. It is less friable than the Plaster, but the proprietor has erected a mill of curious construction, near the quarry, in which it is easily pulverized; and such is the increasing demand for it, that he anticipates much profit from the discovery. Possessing no chemical apparatus, it has not been in my power to make by any means, a complete analysis of this stone. From the slight attempts I have made to decompose it, I am satisfied it is composed of the *sulphuric acid* in no small proportion, *plumbago*, and *siliceous earth.* *Plumbago, in a simple state, is frequently found in the interstices of the quarry.

If I have rightly conjectured its composition, this stone possesses nothing in common with gypsum, excepting

* A small quantity of this is also forwarded.

the *vitriolic acid.* But as its fertilizing effects are the same, or nearly so, it goes far to demonstrate the correctness of an opinion I have long entertained, that the vitriolic acid, by some considered hostile to vegetation, is in truth the only operative ingredient in gypsum. This acid, chemists inform us, will attract six times its weight of water from the atmosphere, before it will be saturated. Now the Plaster of Paris, which is said to contain thirty parts in one hundred, of this acid, produces no effect but on sandy or gravelly soils. It should seem that as fast as the acid attracts the moisture, the thirsty soil receives it, and in this way the plaster becomes a faithful and excellent conductor of humidity to the plant. Whatever may be the cause, it is certain that a small quantity of pulverized gypsum, exposed upon a dry stone to the open air, in a warm and clear day, will presently by the attraction of water from the air, become a mere paste. It is difficult to account for its astonishing effects upon vegetation in many parts of our country, on any other hypothesis.

My principal object in making this communication, is, to obtain a more perfect analysis of this newly discovered manure, in hopes it may be employed to advantage upon the sea-coast, where, I am informed, gypsum produces no visible effect.

The paper No. 2, contains stones of a singular form and appearance, sent me by a gentleman in Winchester, to be communicated. He informs me they are found in considerable quantities in that town, sometimes in large masses, which, when struck with a sledge, will fly into pieces of different sizes, retaining uniformly the hexagonal figure. From their assuming universally the form of hexagonal prisms, and from their transparency and hardness, I conclude they must be, if not the *rock crystal*, at least a very pure species of *silex*. But of whatever substance they are composed, it is possible in the hands of a skilful lapidary, they may be turned to a good account. I am, Sir, respectfully,

Your obedient servant,

JOHN C. SMITH.

S. BALDWIN, Esq. *Rec. Sec. Ac. Ar. Sci.*

No. IV.

SKETCH

Of the Mineralogy of the Town of New-Haven,

IN ANSWER TO THE FIFTH QUESTION OF THE CONNECTICUT ACADEMY OF ARTS AND SCIENCES.

IT will be advantageous to consider this subject under two divisions, which naturally arise out of the diversity of surface by which the territory belonging to the town of New-Haven is strongly marked.

I. OF THE PLAIN COUNTRY.

II. OF THE MOUNTAINOUS AND HILLY COUNTRY.

And I. OF THE PLAIN COUNTRY.

The city of New-Haven stands on the southern part of an extensive plain, bounded on all sides, excepting the south and south-west, by a circular range of elevated ground, rising, in most places, into high hills, and, in two instances, into mountains of considerable altitude. The mean diameter of this plain, which forms an irregular amphitheatre, has not been ascertained by correct measurement, but it probably does not exceed two and a half, or, at the most, three miles. Two rivulets wash the boundaries of the plain, and the bottom of the hills; the one on the east, and the other on the west, and terminate in arms of the sea, or salt water creeks, flowing into the harbor. On the north and north-east, the connection of the plain country with the heights is uninterrupted by water, except that the morass, called the *Beaver Ponds*, breaks the continuity of the plain, about half a mile from the high ground on the north-west.

The plain country, of which I have now given a sketch, presents very little which is interesting to a *mineralogist*. It is not quite uniformly level, but slopes somewhat towards the harbor, and towards the rivers; and there are a few depressions which may be denominated vallies.—The inequalities of its surface are, however, no where so great, as to militate seriously against the idea, that it is principally an *alluvial* country. The conclusion is undoubtedly a correct one, that plain countries have generally been formed, or at least greatly extended, by the demolition of hills and mountains, caused by the long continued operation of frost and wind, rain, heat, and other similar causes, usually described under the comprehensive, although indefinite appellation of the *elements*. It is, however, only in Alpine countries, where the mountains rise to a stupendous height, and are exposed to the full fury of the storms, that one can expect to see the truth of this idea confirmed before his eyes, by the deep channels which a tempest of a few hours continuance will produce, and the great accumulation of stones, gravel and earth which are suddenly precipitated to the plains, and spread out over their surface. But, it is nevertheless true, that even in a country like that which we inhabit, the same causes are at work, and have been, since the creation. Their operation is less obvious, but not less certain, and there can be no doubt that the hills of New-Haven, as well as the Alps, the Appennines, the Pyrennees and the Andes, are wearing away by the friction of time. By the disintegration even of their firmest materials, they are suffering a real and increasing degradation, and in the same degree, do the plains and vallies below, acquire successive strata by the accumulation of their spoils. Indeed, we are not entirely without evidence on this point in the particular case now before us. After torrents of rain, we can, in many instances, perceive masses of gravel and earth, which have been washed down from the hills, and it is not difficult to mark a gradation of stones of considerable size; of coarse gravel; fine gravel, and sand; and lastly, of parts so comminuted that they have become blended with the soil.

It may be thought that the east and west rivers would in a great measure prevent the alluvial increase of the plain of New-Haven, since, whatever is washed from the hills at whose feet those rivers run, must be arrested by them, and be either carried down by their currents, or deposited on their banks, or in their channels.

It is believed however that they have materially contributed to the extension of this plain, and its encroachment upon the harbor, both by the increase of their own banks, and the gradual change of their beds, and by accumulating such masses of matter, as, in the progress of time, have extended the land farther into the harbor, and elevated that into dry ground which was once beneath the water.

An effect of this kind has been manifestly produced, within the observation of people now living in this town, by the two small streams, one of which runs through the city, and the other passes between Meadow-Street, and Sodom Hill. It is well known that the harbor, contiguous to the mouths of those streams, has filled up with remarkable rapidity, and that salt grass is now beginning to grow, in many places, where a few years ago, vessels of 50 or 60 tons might float at high water. Thus, it would not be surprizing, if, in the progress of a century, the greater part of that portion of our harbor which now exposes a bed of mud at low water, should become dry ground.

When these things are duly considered, perhaps the conjecture will not appear extravagant that no small portion of our plain has been formed by *alluvion*, in the long progress of 6000 years, and that the very place which we now stand upon, was formerly overflowed by salt water. It would be easy to fortify this conclusion by many parallel facts, and to show that similar changes are going forward in most countries; but facts of this nature are sufficiently well known, and it remains only to ascertain how far these speculations derive confirmation from the nature of the soil, and of the materials found beneath it.

The soil of this plain seems to have been originally, viz. before it was improved by European cultivation, little more than a stratum of reddish sand, mixed with a small quantity of vegetable mould, arising from the spontaneous decomposition of such vegetables as it was able to produce; and, even to this day, we find it marked by the same character, in those places, where it has not been improved by art. I need only refer, for the proof of this fact, to a space of considerable extent which lies at the foot of *Pine Rock*, and extends to the Beaver Ponds. We find the surface there composed principally of reddish siliceous sand, generally in masses of perceptible magnitude, but variously comminuted from the size of a pebble as large as a hen's egg, to that of a grain of sand. Now this stratum appears to be the fair effect of the alluvion of the neighboring hills, and there seems no ground for making any other distinction between it, and the rest of the surface of the plain, than what has arisen from manuring and cultivation. From these causes it has happened, that a rich vegetable mould is now found on a considerable part of our plain, and that no small degree of fertility has, in many places, succeeded to primeval barrenness.

If we penetrate into the ground, we find reason for extending these conclusions to the strata beneath the surface.

The digging of ditches, canals, cellars and wells, has afforded some opportunity to observe the structure of the more superficial strata. So far as the writer is informed, no quarries or masses of rock have been found, nor any other indications of a primitive country.

The mass of materials is all stratified, and the strata differ from each other only in the size of the individual masses which compose the different gravelly beds.

At the Beaver Ponds, where a canal has recently been dug to drain the morass, a stratum of fine sand has been thrown up, and mixed with it are masses of white quartz of four or five inches in diameter, which have evidently been rounded and smoothed by the friction of other stones and water. The Beaver Ponds are *said* to contain peat.

On the whole, it seems probable that our plain has been greatly raised and extended, if it was not originally formed, by *alluvion*, and in the same proportion as it has acquired successive strata, the surrounding hills have been lowered to furnish the materials; in the same manner, it is probable that all eminences are undergoing a constant degradation, and the plains and vallies by the same means are rising continually, and extending their limits also, where circumstances will admit of such extension.

II. *Of the mountainous and hilly country.*

When we come to examine the heights which encircle the plain of New-Haven, we find a state of things very different from what has been described. Indications every where occur of a very ancient, if not of a primitive country, and in some parts at least, we must conclude that for many ages, if not from the creation, things have remained substantially as they now are.

On the East, at the edge of the plain, rises a perpendicular front of rock about 450 feet high, at the foot of which runs one of the rivers formerly alluded to in describing the plain.

The *East Rock*, as this eminence is called, presents to the eye a range of rude and irregular columns, whose surfaces have been evidently exposed to successive fractures, which have observed something like regularity, being generally found parallel to the *preceding* fractures. In this manner it happens, that prismatic figures of considerable regularity, may be observed on the front of the rock, and, on examining the stones which have fallen in the progress of time, or which have been broken off by the stone diggers, they are generally found to have something of a regular form, in some instances very striking and complete. The most common figures observed here are the triangular, the five and six sided prism, the parallelopipedon and the *rhomboidal* prism. A disposition to assume regular forms is one characteristic of this species of rock, which there can be no hesitation in pronouncing to be what is called *whin stone* in Scotland, *trap* in Sweden, and *basalt* in some countries. The Giant's Causeway in Ireland, and the Cave of Fingal in the island of Staffa, on the western coast of Scotland, are famous, all the world over, for an exhibition of basaltic pillars of astonishing size, number and regularity.

The southern side of the mountain called Arthur's Seat, at Edinburgh, exhibits regular six-sided prisms, and our rocks here show a similar tendency so strongly, that one would, from this circumstance alone, be induced to suspect their identity.

But the matter is placed beyond all doubt by a minute ocular comparison of specimens from the two countries. The writer is in possession of specimens of the different basaltic rocks which are found in the vicinity of Edinburgh, and, on comparing a piece of our East Rock, with a piece of Salisbury Craig, a basaltic mountain near that city, one would be ready to say that they were broken from the same mass. Salisbury Craig is, in appearance, strikingly similar to the East Rock. It has the same rude perpendicular columns, the same curvilinear form, and nearly the same extent: It has a similar sloping mass of ruins accumulated at its foot; it fronts the same way; it slopes off with the same easy declivity in the rear: Like the East Rock, it reposes on a bed of red sand stone; and finally, on fracture, the stone presents the same appearance. So far as it has been examined, its chemical characters appear to be the same. It melts in the heat of a smith's forge, and, on cooling rapidly, presents the same vitreous slag, which the Scotch whin is known to produce. Hornblende and a white substance softer than quartz, probably feldspar, are the principal ingredients of both. The stone is reckoned among the argillaceous class, by some mineralogists, and by others, among the siliceous. The predominant ingredient is certainly silex, or the flinty earth, although when breathed upon, it emits the smell of *clay*, which would induce one to refer it to the argillaceous family.

Dr. Kennedy, of Edinburgh, analyzed several specimens of Scotch Whin. He found the Basalt of Staffa composed of

48	silex	in every 100 parts.
16	argil or pure clay	
16	oxid of iron	
9	lime	
5	moisture and other volatile matter	
94		

By subsequent experiments he ascertained that there existed also in this stone four parts of soda, and one of muriatic acid. The whin stone of *Salisbury Craig*, which is most similar to that of the East Rock, gave

46	silex	in every 100 parts.
19	argil	
17	oxid of iron	
8	lime	
4	moisture and other vol. matter	
3,5	soda or about that quantity	
7	muriatic acid	
98,5		

The same distinguished analyist (Dr. Kennedy) examined several other varieties of whin, and found them composed of nearly the same ingredients.

He analyzed also specimens of lava from Mount Etna, particularly that of Catania, and Sta. Venere Piedmonte, (vid. Edinb. Trans. Vol. v. part I. page 92) and found the most surprizing coincidence in the nature and proportion of their ingredients. It is not proper to demand so much of the time of the Academy as would be requisite in order to enter into the theories of the earth which at the present day profess to account for the origin of whin stone, as well as of the other masses of our globe: yet, it cannot be well omitted, that Europe is now divided between two systems of geology, at the head of *one* of which was the late Dr. Hutton, of Edinburgh; and of the other, the celebrated mineralogist *Werner*, of Fribourg, in Germany. Thence the two systems are called the *Huttonian* and the *Wernerian*, or, because the former employs fire, and the latter water, as the great agent, they are frequently denominated the Plutonic and the Neptunian systems. According to Dr. Hutton, the whin stone is a product of subterranean heat. He supposes it to have been once in a semifluid state, and in that condition to have been forced from below upward among the superior strata by subterranean fire, where, by slow cooling, he imagines it assumed the stony character, and crystaline texture; for, it must not be forgotten, that when whin stone is melted by our common furnaces, and suffered to cool rapidly, it becomes mere glass, and, as the lavas are not viterous, but possess the stony and crystaline character, this was supposed by the opponents of the Huttonian theory, to prove that lava and whin stone could not have had the same igreous origin, since, if that were the case, the melted *whin* ought, on cooling, to assume the appearance of stone, and the crystalized form usually observed in the lavas, instead of the vitreous character which alone, after fusion, it had hitherto exhibited. But this objection has been removed by the experiments of Sir James Hall, of Edinburgh, who has found that when melted whin stone is cooled very slowly, and with a regulated temperature, it resumes completely the stony and crystaline character; moreover, that lava itself, if cooled rapidly, becomes a mere vitreous slag; if slowly, it exhibits again the proper appearance of lava, and that the same specimen of whin stone or of lava may, in this manner, be converted at pleasure into glass or stone, and this as often as the experimenter chooses; nay, that even common bottle glass may, by slow cooling, be converted into a perfect stone, and then by melting anew and rapid cooling, it may be restored to the state of glass again. It has happened to the writer to see most of the original specimens upon which these conclusions were founded.

In the opinion of the Huttonian geologists, they justify the conclusion that lava and whin are both of igneous origin; the former actually erupted into day light, and cooling without any other pressure upon it, than that of the atmosphere; the latter actually melted in the bowels of the earth, and injected among the superior strata, by the force of subterraneous fire, but never erupted like lava, cooling under the pressure of the superincumbent strata; and therefore for which reason it assumes a more compact appearance, free from those cells so common in lavas.

To account for the appearance of the numerous masses of whin stone which we now see above the surface, they suppose that the materials which lay above, have been worn and washed away in the progress of time by the weather, and have left the harder and less destructible masses of whin stone exposed to view.

On the other hand, the Neptunian or Wernerian geologists suppose, that whin stone is a crystaline deposit from an actual state of solution in water.

These ideas, both of the Huttonians and Wernerians, are considered by their respective advocates, as equally applicable to granite, porphyry, and the other varieties of rocks, whose texture is crystaline. Perhaps it would be more correct to apologize for having digressed at all into theories of the earth, where we usually find so much that is visionary, hypothetical or false, than to persist farther in speculations which must at last end where they began, in doubt and painful uncertainty. It will therefore be more expedient to pass on to matters of fact, where we are in less danger of being misled by imagination.

South-east of the rock which we have been considering, are two eminences, lying in the same chain or ridge with the East Rock itself. The first of these is compact whin stone, and the faces of the stone are remarkably regular in their fracture, presenting frequently the rhomboidal prism. On the front of the other eminence, about two thirds of the way from its base to the top, and on that part which inclines towards the East Rock, we discover a bed of sand stone, having large and distinct masses of quartz imbedded in it. The strata are inclined a little to the east, and apparently sustain the bed of granitic whin, which forms the mass of the eminence itself. The materials which compose this eminence, are considerably different from those of the adjacent mountain.

They present very distinct crystals of feldspar, and quartz in abundance, but the mica, the other ingredient of granite, is wanting, and we find little or no hornblende so common in the contiguous whin stone mountain. These are however some masses of compact, fine grained black basalt lying upon the hill; and upon the whole, we must pronounce it *granitic*, although it is not granite, and inclining to whin, although it is not whin stone. It must be regarded as one of those masses which form a connecting link between whin stone and granite, for it must be remembered that granite, whin stone and porphyry graduate insensibly into each other.

Leaving the East Mountain, and its dependencies, we come next to that chain of high ground, which passes immediately *west of*, and parallel *to*, the Hartford turnpike road, and terminates near the new burying ground. Here we shall not be detained long. The basis of the hill appears to be a very coarse grained and friable red sand stone. Upon its surface lie here and there, fragments of granite, in many of which the feldspar is undergoing decomposition, and becoming porcelain clay. It is, probably, from the decomposition of the feldspar of granite, that the porcelain clay is principally formed.

Most of that used in England is obtained from Cornwall, where extensive hills or ridges of granite are now undergoing decomposition. On the hill under consideration, is found abundance of quartz, white, brown, and red; and masses of flint are not unfrequently met with.

Proceeding in our survey, we arrive next at the PINE ROCK, lying north-west of the Beaver Ponds, and east of the West Rock. Pine Rock is a mass of WHIN STONE, scarcely distinguishable in fracture, grain and colour, from that of the East Mountain. It contains however, veins of *phrenite* in radiated crystals, and tremolite crystalized in diverging lines, grouped together like *radii* of a circle. It is somewhat gratifying to find these crystalized substances, so common in the whin of the *old* world, associated also with that of the *new*, and thus confirming the correctness of our conclusions concerning its nature. Upon many of the masses of the *Pine Rock*, and particularly upon a large part of that projecting brow, which forms what is called the Judge's Cave, may be observed a white saline efflorescence which, from its taste, appears to be sulphat of iron, more commonly known by the name of green vitriol, or copperas.

Should this impression prove correct, it would not be difficult to account for the formation of the substance in question, since the sulphur which exists in these rocks in the form of pyrites, might be acidified by the oxigen of the atmosphere or of water, and the sulphuric acid thus produced, attacking the iron, either of the pyrites, or of the whin itself, would necessarily form copperas; the water would disolve and carry it over the surface of the stones, and evaporation would at last leave it in the dry powdery state in which we find it.

The mountain called the West Rock, which occurs next on our circuit, is a grand basaltic ridge, where the columns are more lofty, the prismatic form is more distinct, and the mass of ruins at the foot of the perpendicular cliffs is more considerable than at the East Rock.

There is however very little in its mineralogical history which has not been already anticipated. It is said to be incumbent upon a bed of sand stone; this however was not ascertained by actual examination.* That the *Pine Rock* has such a basis, is evident to the eye, for the strata are distinctly visible at one end of the eminence, where they have been laid bare by the rains. It will be well to remember that the whin rocks about Edinburgh have the same basis, and we have already found the same fact at the East Rock as well as here.

If there be any difference in the appearance of the whin of the West and of the East Rock, it may perhaps be said, that the former contains more hornblende, and is more inclined to break into the rhomboidal prism. The tendency of whin stone to assume these regular forms contributes very much to the utility of this stone, which thus presents fair faces for walls, and is easily made to tally with contiguous stones.

* *Note.*—I have since ascertained this to be the fact.

We cannot leave the whin stone mountains, without adverting to the enormous accumulation of the fragments of their columns, which is found at the foot of all of them, which the writer has seen, either here, or in Scotland. These fragments, which have every possible size, from a few grains weight, up to 100 tons, very naturally result from the innumerable seams which divide even the firmest whin stone rocks, into what may be considered as a collection of columns, standing side by side, and so contiguous, as, on the whole, to form one solid mass. Other fractures run at right angles to these, in such a manner as to cut off the perpendicular columns into blocks of various lengths. It happens therefore, that whenever the tops of these columns become exposed to the atmosphere, in consequence of the washing away of the less consolidated matters which cover them, they become peculiarly liable to break off by the action of the weather. This occurs particularly from frost. The water insinuates itself into the crevices, and when it freezes, it happens, in consequence of the well known expansion of water, during its congelation, that the columns become strained, and have a tendency to separate, whenever the cohesive force of the ice is diminished; therefore, especially in the spring, when the ice thaws, not only small masses, but even large columns, break off by their own weight, and fall to the bottom. At the *West Rock* particularly, one may see enormous masses which have fallen in this way; and such is the accumulation which time has produced there, that a sloping mass of ruins now extends more than half way up the mountain, affording strong confirmation of what was advanced in the early part of this essay, concerning the gradual demolition of hills and mountains by the action of the elements.

The subject of the whin stone mountains (already extended perhaps too far) shall now be dismissed, with the single remark, that the columns so often alluded to, are not always perpendicular; sometimes they are greatly inclined; a remarkable instance of which occurs at the junction of the Hartford and Cheshire turnpike roads, near Mr. Whitney's, where the columns do not form an angle if more than 8° or 10° with the horizon, and rest upon a stratum of sand stone, having the same inclination in degree and in direction, which is southwest.

From the West Rock, we bend our course westward and southward, along the brow of the hills, which now assume only a very moderate elevation. Frequent masses of granite, whin stone, quartz and *sand stone* accompany us along through Westfield, till we arrive within a quarter of a mile of the Derby turnpike, when a new species of stone presents itself, and very soon becomes the predominate stone of the country. Its color is bluish, inclining to white, its fracture hackly, its hardness is such that it may be scratched even by the nail. Its structure is schistose, the laminæ are often variously contorted, and frequently striated, with laminæ of quartz, and sometimes of mica, so that in many places it may be called *micaceous schistus*, and from its soapy feel it may generally be denominated *magnesian schistus.*

There are considerable varieties in its appearance; sometimes it inclines towards argillaceous schistus, or slate, but is distinguished from it, by its soapy feel, and, other times it approaches the character of serpentine. Here and there in this quarter, may be seen detached masses of porphyry, which seems capable of receiving a handsome polish, but no bed of it was observed, although it is more than probable it exists in the adjacent hills in considerable quantity.

Nothing occurs to detain us in passing over the hills which lie between the Derby turnpike, and those heights which overlook West-Haven, about midway between the Sratford road, and the Sound. Insulated blocks of granite, whin stone, porphyry and quartz are scattered every where along, but the magnesian schistus is predominant, and from the heights just now mentioned, to where they terminate in the flat ground, adjacent to the shore, we find nothing but immense strata of this *magnesian schistus,* rising every where to view, and discovering, whenever the road, a water channel, or a side-hill gives a view of the strata, an unvarying inclination to the west and north, forming an angle of perhaps 35° with the horizon.

In some instances this schistus is sprinkled with beautiful spangles of golden coloured mica, which are very brilliant in the sun.

We have now made the complete circuit of the hills of New-Haven, and the Academy are in possession of the result of an investigation, which, from its being probably the first of the kind attempted in this State, may perhaps have some right to claim, as it will undoubtedly need, an indulgent reception.

Nothing has been asserted which has not been ascertained by actual examination; and if there are errors, they are not the result of indolent and remiss inquiry, but of deficient information, or erroneous judgment.

If however, this imperfect investigation should prompt to similar exertions throughout our state, the effort will not have been lost, and may lead to such discoveries as will certainly be subservient to science, and may not improbably open new sources of domestic wealth, and materials for architectural and manufacturing industry.

B. SILLIMAN.

YALE COLLEGE, *Sept.* 1, 1806.

No. V.

NUMBER OF DEATHS,

In the Episcopal Church in New-York, in each month for ten years—from January 1, 1786, *to Dec.* 31, 1795.

TAKEN FROM THE SEXTON'S BOOKS, AND COMMUNICATED

BY N. WEBSTER, ESQ.

Ages.	Jan.	Feb.	March,	April,	May,	June,	July,	Aug.	Sept.	Oct.	Nov.	Dec.	*Total.*
2 *years and under,*	66	43	48	58	51	70	173	360	261	139	78	93	1440
Between 2 *and* 5,	12	12	14	7	5	11	8	21	18	25	25	14	172
5 *and* 10,	8	13	8	4	14	7	11	14	15	17	5	16	213
10 *and* 20,	7	5	6	5	13	4	7	8	25	12	7	8	107
20 *and* 30,	23	16	18	16	17	16	20	28	53	26	20	21	274
30 *and* 40,	14	24	12	16	25	18	29	28	36	36	24	24	286
40 *and* 50,	40	35	21	32	45	26	30	33	57	53	38	38	448
50 *and* 60,	11	23	17	16	25	23	18	28	22	23	20	11	237
60 *and* 70,	5	18	13	4	19	15	12	8	10	11	11	7	133
70 *and* 80,	6	8	7	4	10	4	7	6	7	6	9	9	83
80 *and* 90,	1	4	5	6	7	3	3	1	3	2	3	5	43
90 *and* 100,	0	1	1	1	3	1	2	0	1	4	0	2	16
100,	0	0	0	0	1	0	0	0	0	0	0	0	1
104,	0	0	0	1	0	0	0	0	0	0	0	0	1
													3373

It appears that in the four months of July, August, September and October, being one third of the year,

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there died 953 children of two years old and under—almost two thirds of the whole number of deaths.

The influence of summer heat upon young children is apparent from the increased mortality in the month of July—an equal increase not taking place so early among the adults.

Of one hundred persons that die in New-York, according to this bill of mortality for ten years, there die of

Two years old and under, - - -	43
Between 2 *and* 5, - - -	5 1-10
5 *and* 10, - - -	3 6-10
10 *and* 20, - - -	3 1-10
20 *and* 30, - - -	8 1-10
30 *and* 40, - - -	8 5-10
40 *and* 50, - - -	13 3-10
50 *and* 60, - - -	7
60 *and* 70, - - -	3 9-10
70 *and* 80, - - -	2 5-10
80 *and* 90, - - -	1 3-10

One to 211 dies between 90 and 100.
One to 1686 dies above 100.

In this account, children who had completed two years of age are included in the first number, contrary, I believe, to usual practice. It is proper to remark the great proportion of deaths between the ages of 40 and 50. This proportion is far greater than it is in country towns.

This period of ten years, from 1786 to 1795, inclusive of both, was marked by several epidemic diseases, the measles and whooping cough and scarlatina Anginosa, which increased the mortality among children in 1789, 1792 and 1793—and the yellow fever increased the mortality among the adults in 1795. Taking the five healthy years of the period, viz. 1786, 1787 and 1788, 1790 and 1791, and the proportion of children of two years and under, is nearly 46 out of a hundred, not including premature births.

No. VI.

AN ACCOUNT

Of the American Cantharis, or Meloe Americæ;

COMMUNICATED BY DOCT. NATHANIEL DWIGHT,
NOW OF NEW-LONDON.

IN the Medical Repository, No. II. vol. II. page 174, is the following account. " Two or three years ago, William Smith, an intelligent person in my neighbourhood, informed me that one day as he was at work, he accidently mashed an insect on his shoulder, which, in a short time, produced a complete vesication; and it appearing to be the insect here described, I was determined to gather some of them, and give them a trial in my practice; which, however I neglected to do until last summer.

" This insect has a very near resemblance, in outward form, to the Meloe (vesicatorius) alatus, viridissimus nitens, antennis nigris, (Linn.) or Spanish flies, as they are commonly called; but is rather smaller than even those brought from Spain, and of a very different color; the head is of a very light red, with black antennæ; the elytra, or wing cases, are black, margined with pale yellow, and a stripe of the same color extends along the middle of each of them; the tarsi have five articulations;

the mouth is armed with jaws, and furnished with palpi," &c.

After reading the above account, together with the successful experiments made by Dr. Chapman, its author, I began, early in the summer of A. D. 1800, to search potatoe patches in Farmington, to see if I could discover the insect; but my endeavors were fruitless, till some time in August. I had, indeed, seen a few which were gathered in the city of Hartford, early in the month of July, which answered to Dr. Chapman's description, in every particular. Had this proved the case in my subsequent endeavors, I should have rested contented with his account; but since it was far otherwise, I have taken the liberty to communicate the result of my enquiries on the subject.

In the latter part of August, I was applied to by a man in Bristol to visit his daughter; and when riding to his house, he commenced a conversation about the Spanish flies, which induced me to suggest the sum of Dr. Chapman's account (above referred to) to him. He replied, "I believe I can show you enough of them on my potatoes; for they have been almost destroyed by a bug this year; and some of my neighbors' are much worse than mine." I was glad to embrace the opportunity; and after visiting the child, we took a walk together into his garden, where, to my great astonishment, and no little mortification, I saw the potatoes almost covered with an insect entirely black. On examination, however, I perceived that they answered perfectly to the above description by Dr. C. except in color. Looking a little farther, I found a few which came still nearer to his account; and still these varied very materially. They had their elytra margined with a narrow stripe of a light dirty brown. In every other respect they were like the others.

This suggested to me the probability that they were subject to change their color as the season advanced; but it is only a probability still, since I have not had any opportunity to determine it by fact. This probability is strengthened by analogy.

In pursuance of my investigation, I perceived that those with the margined elytra, and the black ones, copulated promiscuously, and that there appeared to be males and females of both kinds.

Some days after this, as Dr. Todd and myself were riding together, I mentioned to him what I had discovered, and, soon after, coming up to a potatoe patch, I discovered one of the black kind, and caught it. Dr. Todd rubbed it, for perhaps three seconds, upon his wrist, without mashing it, and called on me to notice the place. In riding one mile he complained of an itching, mingled with a burning sensation on the spot; which, on examination, was perceived to be a little red. In about one hour we caught some more, and found them of both the kinds above mentioned, but none which answered Dr. C.'s description. Dr. Todd then applied a second, of the black kind, in the same place, and in the same manner; when he mentioned to me, that the pain was excessively severe, and in a few minutes, on examination, we perceived a vesication had begun. I did not see Dr. Todd, until two or three days after this time; when he showed me his arm, and there had been a complete vesication, as large as the utmost bounds of the application of the insect, and larger than either of us had supposed he rubbed it on the skin.

Dr. Todd informed, that he was at Southington a day or two before, and on mentioning the above fact to Dr. Wadsworth, he, with his son and Dr. Todd, went into a plot of potatoes, and found the flies in plenty;—that Mr. Wadsworth applied one to his flesh, (I do not now remember where,) and that it became red in a few minutes. I have not learned the final result of it.

If they are other where no more plenty than where I first saw them, I presume that a child of ten years old, furnished with a convenient apparatus for confining them after they were taken, might gather a pound, at least, per day. Those that I saw, flew but little, nor did they make any other attempt to escape being taken, only to fall from one leaf to another; and, if pursued, they would contract their legs, antennæ, &c. and fall, apparently, lifeless to the ground. Some, I saw, running into little perforations in the earth, of which there were many under those potatoe hills where the insects fed. But I could not satisfactorily determine whether the insects made them, or whether being otherwise made, the insects casually fled into them as a place of safety.

I had some gathered by the father of the child, of both kinds, separately; but as they did not readily die, by the method which I recommended, (viz. to put them into a covered glass, and that into a vessel containing boiling water,) he poured some water, as he said, almost scalding hot, into the glass. On mentioning the fact to me the next day, he observed, that there arose such a fume from the glass, as almost stopped his breath. I asked him if it was equally the case with both kinds? He replied, that he saw no difference. It remains yet to be proved, whether those killed in this manner, will produce the vesicative effect. This experiment I shall not fail to try, and will endeavor to communicate the result to the Academy.

As I think the experiments published in the account above refered to, by Doctor Chapman, abundantly prove the vesicative quality of this species of the cantharis, I should not have transmitted this statement to the Academy, had his description been perfect. But, as some of the distinguishing marks which he has there given, do not at all exist on by far the greatest part of those which I saw; and as none of them answered perfectly to his account, I have thought it proper to communicate these facts, with a view to obviating mistakes which might ensue, were people guided solely by his description in gathering them; and also to render their history as perfect as may be.

FARMINGTON, *Sept.* 9, 1800.

No. VII.

A CALCULATION

OF THE ORBIT OF THE COMET,

Which lately appeared; together with some general Observations on Comets.

BY COL. JARED MANSFIELD,

SURVEYOR-GENERAL OF THE UNITED STATES.

ABOUT the latter part of September, some persons living in the vicinity of this place, gave notice, that they had seen, for several successive evenings, an uncommon kind of Star, which, from their description, I concluded must be a Comet. On the first of October, through intervals of clouds, which were flying, I had a momentary view of the object, which, from its situation in the heavens and crinited appearance, obviously could not be one of the fixed stars, or planets. By the observations of a few evenings after the 1st of October, the general direction of its motion, as seen from the earth, was readily discovered, and it was evident that this comet, or wanderer, was retiring from its visit to the sun, or that it had passed the Perihelion, and ascending node of its orbit, and was receding from the regions of the planets. These circumstances were unfavorable to the views I had entertained of observing its motions, in such situations of its orbit, and during such long intervals of time, as would be requisite for an exact determination of what astronomers call the *elements of its orbit*. Nevertheless, I endeavored, for this purpose, to improve such advantages and opportunities as were presented; and the common distance from some known fixed star was taken every night when the sky was clear, from the 1st of October, to the time of its becoming invisible. The only instrument which could be used for this purpose, was a well divided Sextant belonging to the United States. From the nature of the instrument, and the unfavorable state of the atmosphere during a considerable portion of the time, when the observations were made, I am far from thinking, that they will bear a comparison with such as may be made at European observatories. In my opinion, however, they will be sufficient for determining the orbit of this Comet, with as much or more accuracy, than some of those of the preceding centuries, on which Dr. Halley and other astronomers have grounded their calculations of a number of comets.

With a view of investigating the elements of the orbit of this comet, I selected three observations made at equal intervals of time, viz. those of October 3d and 19th, and of November 4th. Others might have been used for this purpose, but these superseded the necessity of interpolation, or of using the differential method of Newton. The geocentric longitudes and latitudes of the comet for those times, were calculated, and its velocity, and the apparent direction of its motion in respect to the earth, were thereby found. The direction of the plane of its orbit, and its distance from the sun, at one of those times, were found nearly, by a comparison of the absolute quantity and rate of its velocity in a parabolic orbit, with its apparent angular motion as seen from the earth, during the intervals of time between the observations. A calculation was then made, of different orbits varying in excess or defect of distance from that assumed, and an orbit was found by proportion, which gave the comet's place very nearly as observed.

These calculations being very tedious, and there being great danger of incurring mistakes, I have not been able to pursue them, to the extent which might be desirable. Those who have more leisure, may at any time enter on a more minute and precise investigation. It is probable however, that the errors of the observations will exceed those of the calculation I have made, in their effects on some of the deductions. The following are the results of that calculation.

Place of the ascending node,	8*s* 27° 08′
Place of perihelion,	8 28 48
Inclination of its orbit to ecliptic,	0 63 09
Perihelion distance, that of the earth from the sun being 1,	.64480

Time of being in perihelion, Sept. 18th, 12h. 40m. P. M.
Time of its being in ascending node, Sept. 17th, 3h. P. M.
Motion of the comet, *direct.*

Remarks. This comet approached the sun from the regions of the south, and first became visible to an inhabitant of the earth, about the 25th of July last. From that time, it might have been seen by those who live in places of considerable south latitude; but on account of the great inclination of its orbit to the ecliptic, and its little elongation in longitude, during all the time of its approaching to, and part of that of its receding from the sun, it could not be seen by the inhabitants of Europe, or of the United States, till towards the end of September. After this, its elongation, in north latitude, was increased, so as to give it an elevation above the horizon, which caused it to be visible after sun-setting. It disappeared to the naked eye, about the beginning of November, but was discernible with a telescope towards the end of that month.

From a comparison of the elements as above stated, with those of 78 comets observed by European astronomers, during the two or three last centuries, it does not appear, that this comet is one of that number. That of 1684, calculated by Dr. Halley, agrees nearest with this, in all the elements, except that of perihelion distance; but this alone, if the numbers, as deduced by that great astronomer, be correctly stated in the books to which I have had access, is a decisive evidence, that they are not

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one and the same comet. For however appearances in other respects may be, the eccentricity, or that which is nearly commensurate with it, (perihelion distance,) is the most material element by which the identity of their *orbits* could be ascertained. Though this comet may have made one or more revolutions about the sun, since astronomers have begun to watch the motions and appearances of comets, there is reason to believe, that it has hitherto escaped their observations; for, in most situations of the earth in its orbit, the comet could not have much elevation above the horizon of places of any considerable latitude in the northern hemisphere, so as to be seen out of the effulgence of the sun's rays, till it had so far passed the perihelion, as to be scarcely distinguished from other celestial bodies, by its splendor, or crinited appearance.

Compared with some comets, whose tails have extended from 70 to 120 degrees over the horizon, that of this comet was by no means remarkable. The extent, at most, was not more than 8 or 10 degrees, when first observed, though the comet, at that time, had passed its perihelion, and its situation was such as to cause a great extension of its coma, or the atmosphere of its head. This coma appeared to be very thick about the nucleus, and its opacity much diminished the light of the star, which much resembled the dimness of Saturn. The apparent diameter of the comet's head was much greater than could be expected in one of so little splendor, and at so great a distance from the earth. Though I had no means of measuring it, I am confident, that it exceeded in this, many great comets, such as those of 1680, 1759, and 1769; for these, though remarkable for the length and splendor of their tails, were by no means so, on account of the size or magnitude of their heads. There were no other phenomena, peculiar to this comet, which came under my observation.

Since the discovery of those principles of motion, and gravitation, which regulate the heavenly bodies in their revolutions, the orbits of comets have been calculated with much precision, as it respects that part of them, which lies near the sun and earth. The principal *deside-*

ratum in cometography, and I may say in astronomy, is that of the periodical times of the comets. At first view, it may appear surprising, since the other elements are attainable to a great degree of accuracy, that this should yet be unknown. The same process, by which other elements of a *planet's* orbit are determined, will also determine that of their periodical times; and why, it may be asked, does this not result from a similar process for investigating the orbit of a comet? In answer to this, I would observe, that the orbits of planets vary little from circles, and consequently their periodical times may be found nearly, by a comparison of their velocities with that of any body moving in a circle about the center of their orbits. The variation of their velocities, arising from the deviation of their orbits from circles, may also be determined; as that deviation, in its incipient state, or while the planet's orbit is an ellipsis, differing little from a circle, is very great, compared with its effect in respect to the periodical time, and is therefore susceptible of determination, either from observations of the planet's distance from the sun, or of its velocity. But the orbit of a comet, is a very eccentric ellipsis, whereof the deviation of curvature from that of a circle has arrived nearly to its limit; and the variation of curvature among ellipses of this sort, on which the proportion of their axes, or of their periodical times depends, is so minute, as scarcely to be perceptible near the extremity of their longer axes, or in the comet's orbits near the sun and earth, where only they become visible to an observer on the earth. For this reason, a parabolic orbit has been assumed by astronomers, as sufficiently accurate for the calculation of every phenomenon, incident to a comet's motion within the sphere of the planets. The periodical time in a parabola, or an ellipsis, the ratio of whose axes is *infinite*, if I may use the expression, is *infinite;* yet the curvature near the extremity of the axes of such a figure, differs little from that of an ellipsis, whose axes are in a ratio of no great finite magnitude. Thus, in an ellipsis, whereof the ratio of the axes is as 10 to 1, the difference of its parameter from that of a parabola, the distance from the vertex being the same, is only as .0004, and a centripetal force commensurate with this, would change such an orbit from *finite* to *infinite*. Hence it is evident, that the periods of those comets, which run into very eccentric orbits, cannot be calculated, *a priori*, from any observations of their motions made from the earth. Those mathematicians, who have attempted to derive the elliptical orbits of comets in this way, have failed to produce results, in any degree corresponding with phenomena. The periodical times of the comets must, therefore, remain unknown, till a sufficient time has elapsed for finding them by observations of their returns. It will readily be conceived, that many ages must pass away, before such observations on all the comets can be obtained. But supposing this to have been accomplished, there would still remain an uncertainty in respect to their future periods. One, or more revolutions being completed in a certain time, will by no means justify the inference, that this will be the case in other revolutions; on the contrary, it would be consistent with physical principles, if the period of the same comet be at one time, twice or thrice, more or less, than at another, and even that it be infinitely greater, or never return. Modern astronomers have found, that agreeably to the principles of gravity, the planets, by their actions one on another, are considerably disturbed in their motions about the sun, and that the form and position of the orbits in which they move, are thereby not a little affected. The same causes operating to the increase or diminution of centripetal force, or of the velocity of bodies moving in very eccentric orbits, will, as it respects the figure and dimensions of their orbits, produce effects vastly great, compared with those of the planets on one another; and the periodical times will be in proportion to those effects. If for example, the ratio of the axes of an ellipsis be as 10 to 1, which by no means is equal in eccentricity to the orbits of some comets, and the velocity of the body moving in its circumference, be increased by one five hundredth part of that with which it moves, the body would no longer move in the ellipsis, but in a parabola, in which it could make no return; and if the ratio of the axes of the ellipsis be as 100 to 1, an addition of one fifty thousandth part of its velocity would produce the same effect.* It is evident, therefore, that the returns of comets to the sun, are not only liable to great variations in respect to time, in consequence of the actions of the planets, but that these actions may be so considerable, especially on comets of very eccentric orbits, as to cause them never to return.

Some astronomers have ventured to predict the returns of comets on the principle of their uniformity, as to the times of their revolutions, with as much certainty, and attention to minute accuracy, as are due to deductions founded on the strictest principles of the mathematics: But the only instance of such predictions being verified in any degree by events, is that of Dr. Halley, in respect to the comet of 75 years. This comet having appeared, several times, at nearly equal intervals, induced this astronomer to hazard a conjecture, that it would again return in the year 1758. The comet did indeed appear, at a time not differing more than 12 or 14 months from that predicted; but this variation of time, in respect to different revolutions of this comet, whose orbit has so little eccentricity, is a fact corroborating the statement I have made, of the effects which might be produced by the attractions of the planets on comets whose orbits are very eccentric, such as those of 1680, 1769, and many others, which have been observed during the two last centuries.

The identity of the comets of 1532, 1661, has been considered as certain; and its return in 1789 or 1790, at an interval of 129 years, was predicted to the minuteness of hours and minutes, by a celebrated astronomer, now living. The comet, however, did not at that time appear, nor has it been observed since. I am far from thinking that this, or any of the comets, have been known to make more than one revolution about the sun,

* See Prop. 16, and Corollaries, of Book I. of Newton's Principia, where it is demonstrated, that the velocities requisite for bodies moving in different conic sections, the focal distance of the vertex being the same, is in the sub-duplicate ratio of their principal parameters.

except that of 75 years, whose returns appear to have been observed by astronomers, several times in succession; yet admitting those of 1532 and 1661 to be one and the same comet, it is evident, that its periodical time must have varied from that of its preceding revolution; and if this be the case, it furnishes another fact illustrative of the theory which I have advanced.

Dr. Halley, in his cometography, prompted, undoubtedly, by that enthusiasm which he felt for scientific improvement, says, that "time will reveal to posterity all the mysteries of comets," or in words to this effect. But when the causes, which retard the progress of this branch of science, are duly considered, few will hesitate to adopt the contrary opinion, that ages will pass away before mankind can attain to much more knowledge of the comets, and that the periods of many will ever remain a problem, above human research and investigation.

Cincinnati, Jan. 24, 1808.

No. VIII.

OF THE FIGURE OF THE EARTH.

BY COL. JARED MANSFIELD,

SURVEYOR-GENERAL OF THE UNITED STATES.

THE celebrated question concerning the true figure of the earth, so much agitated by rival philosophers of the last century, is one of the many in astronomy and physics, the solution of which is almost wholly dependent on the mathematics. It is true indeed, that physical considerations of the nature of gravity, and the rotary motion of the earth, first suggested to Newton the idea that its figure must necessarily differ from that of a perfect sphere or globe. This sagacious philosopher and mathematician was likewise enabled, by the use of his own sublime geometry, to determine *a priori*, whatever is required in this problem, with a wonderful degree of precision. But the physical principles of Newton had not yet been verified by a sufficient number of experiments and observations; and the method of *Induction* on which they were founded, must ever be inferior in evidence, to the pure results of the mathematics.

In order, therefore, to a complete and satisfactory solution of this problem, as well as for an investigation of the principles and conclusions of Newton, it was necessary to have recourse to an actual mensuration of the earth, both in respect to magnitude and figure. The first of these, viz. the magnitude of the earth, on the supposition of its entire sphericity, or globular figure, is easily determined. It is only requisite that the whole, or some given part of one of its great circles, be ascertained according to known measures. With this view, the arch of the meridian has been selected, as best adapted to celestial observations. This work, for nautical and astronomical purposes, has been performed long since by Picard, Norwood, and others. The more general question of the earth's figure, which necessarily involves that of its magnitude, is of a different nature; and though not difficult to those who are well versed in the higher geometry, is considerably remote from ordinary investigations. Its analysis affords an illustrious instance of the utility of those abstract mathematical speculations, which we have partly derived from the Greeks; but for which we are chiefly indebted to the moderns, viz. Des Cartes, Huygens, Clairaut, the Bernouillis, D'Alembert, Euler and Newton.

The question may be propounded in general terms, thus: *To determine in any curve, but more particularly in the conic sections, the dimensions of that curve; or the principal lines which regulate it, the diameter of the Osculatory circle, in two or more points of the curve being given.*

The Osculatory circle, or circle of curvature of any curve, is that which not only touches the curve in a point, but so nearly coincides with it, that no other circle can be drawn between them. The curvature of the curve, and circle, in that point, is therefore considered as the same. As this curvature, however, in all curves, the the circle only excepted, is perpetually varying; it can be considered the same no where but in the very point of Osculation, or very near it. The measure then of a small portion of the curve at or near this point, may be obtained from the corresponding portion of the circle, and *vice versa*, that of the circle from a portion of the curve.

The osculatory circle of any two points of the meridian of the earth, be the curve of any kind whatever, may be found by the mensuration of a small portion of it, at those two points corresponding to any small arc, or amplitude; or by the distance of lines perpendicular to the tangents in those points, whose intersection constitutes a small known angle, suppose of one degree. A degree of this circle being known, the circle itself is known; and if this be known in two or more points of the curve, the dimensions of the figure, viz. the ratios of the axes, ordinates, parameters, &c. may be found.

With a view to the foregoing process, mathematicians, in order to determine the figure of the earth, directed the measurement of a degree to be made in two or more distant parts of the meridian; where, supposing the figure elliptical, the curvature must necessarily have a perceptible difference. If these requisites could be obtained accurately, the conclusions respecting the form of the earth were considered as incontrovertible as any propositions of Euclid; and as ultimately decisive of the dispute which had been, for a long time, maintained on this subject. For Cassini and his followers had opposed the deductions of Newton, wholly on the ground that the measure of a degree of the meridian near the pole, would be found less than that of one near the equator; which opinion he was led into from a comparison of the lengths of the arches, which had been imperfectly measured by Snellius, Picard, Musschenbroek, and others.

The Newtonians, on the other hand, maintained that these measures were not sufficiently accurate, or properly adapted to the determination of this question; but if an exact mensuration could be made of the length of a degree of the meridian near the pole, and also at or near the equator, that all physical arguments, which in themselves are merely probable or hypothetical, must yield to the certain and demonstrable conclusions of the mathematics. For, if the measure of a degree at or near the pole, should be found less than one at or near the equator, the axis of the earth must necessarily be longer than a diameter of the equator; and on the contrary, if the length of a degree at or near the pole should be greater than one at or near the equator, the equatorial diameter of the earth must necessarily be more extended than its axis. These deductions, though not obvious, are not less certain than any other mathematical truths, and were never, I believe, called in question till lately; when some philosophers apparently ignorant of the mathematics, from a very partial and superficial view of this subject, have attempted to derive conclusions directly contrary to the foregoing. They have undoubtedly fallen into this mistake from the analogy which subsists between the problem which relates to the figure of the earth, and that of its magnitude, on the supposition of a globular form. For as in two globes, that which has a degree of a great circle the largest, is of the greatest diameter or radius; so likewise they imagine, in a body bounded by any curvilinear superficies, that the degree of the curve is the largest, where the superficies is most remote from the center of the body. It is easy to demonstrate that nothing can be more erroneous than this assumption, and that in attributing false *conclusions* to mathematicians, they have overlooked the futility of their own *premises*, which, in fact, have no relation to the subject, nor any foundation on the principles of science.

They take for granted, that the measure of a degree, on the superficies of the earth, is the measure of the same portion of a circle, whose center coincides with the center of the earth, even while they suppose its form to be spheroidical. From which it would appear, that they had not extended their ideas of the nature, and properties of curve lines, beyond their first and most obvious principles.

In a circle, the measure of a degree of the circumference, is the same as that portion of it, which is intercepted by lines forming an angle of a degree at the center of the circle; and this is the very essential property of a circle, that its circumference be the equable measure of angles at its center. In the ellipsis, and other curves returning into themselves, the measure of a degree of their circumference, or of the osculatory circle, in no instance is the same, as that portion of it which is determined by the measure of a degree from the center of the figure. In proportion as the radius of curvature approaches to the position, and length of a line drawn from the center of the figure, to a point in the circumference, the curve approximates to a circle, and becomes one when those lines coincide.

The portions of the circumference of any figure, corresponding to measures of angles at its center, the circle only excepted, are, and ever must remain unknown till its nature and limitations are determined from other principles. *e. g.*

In the ellipsis* PEpe, the measure of a degree at P, is not the measure of a degree of a circle, whose center is at O, the center of the ellipsis; but it is the measure of a degree of the circle of curvature, whose center is some where beyond at C; and in like manner, the measure of a degree at E, is not the measure of a degree of a circle, whose center is at O, but the measure of a degree of the circle of curvature, whose center is somewhere at *d*, nearer the point E.

What the lengths of those portions of the periphery may be, which correspond to given angles at the center of the figure, is impossible to determine, in the case of the earth's mensuration, as we cannot go to its center, nor make observations on its surface, which supposing the earth's figure and magnitude unknown, can afford the necessary data for the determination of this point. It is evident, therefore, that it is not as in ordinary calculations, from the measures of angles at the center of the figure, that we can obtain a solution of the problem of the figure of the earth. If this could be obtained by no other methods, it is certain that it would for ever remain a secret. But by the aid of that sublime geometry, which in modern times has been so happily employed in abstruse and difficult inquiries of this nature, the problem will admit of a complete solution, from very simple *data*. Nothing more is requisite, than what was supposed above, viz. the measure of a degree at P and E, or at the polar and equatorial diamaters, if the figure be an ellipsis; for then the diamater of the circle of curvature will be exactly equal to the parameters of the diameters at those points, which being known, the ellipsis itself will be known.

The same *data* for any two other points of the meridian, is also sufficient, provided those two points be not

* See Fig. 5, plate 1.

taken too near each other. It will be necessary, however, to have recourse to an analytical process, when the measures of a degree are not at E and P, in order to investigate the relation of the principal lines involved in the general expression, given by mathematicians for the radius of carvature. For it is to be observed, that as in a given ellipsis, the radius of curvature, or the diameter of the osculatory circle, is determined from the principal lines, viz. diameters, ordinates, &c.; so also, when the radius of curvature is given, the principal lines, which regulate the figure, may be ascertained: this will be exemplified in the following

PROBLEM.

The measure of a degree, in two known latitudes of the meridian, being given, to determine from thence, the figure of the earth.

From physical and other principles, it is known that the earth, if not a sphere, must be a solid generated by the revolution of an ellipsis about one or other of its axes. Let therefore the ellipsis* PEPE, be a meridian of the earth, without knowing which axis is the longest. A one latitude and B another, where the measures of a degree are known, AD, BF, perpendiculars to the tangents, at the points A and B, and cutting the diameter EE, in D and F. GD, IF subnormals to the same.

A degree being known at the points A and B, the radius of curvature is likewise known, for each respectively, which let be represented by R, and r, and put the ratio of CP to CE, that of p to q. From the nature of the ellipsis, we have $AD = \frac{p}{q}\sqrt{q^2 - CG^2 + \frac{p^2}{q^2}CG^2}$; $AG^2 = \frac{p^2}{q^2}\,\overline{q^2 - CG^2}$, and $GD^2 = \frac{p^4}{q^4}CG^2$; also $BF = \frac{p}{q}\sqrt{q^2 - CI^2 + \frac{p^2}{q^2}CI^2}$. $BI^2 = \frac{p^2}{q^2}\,\overline{q^2 - CI^2}$, and $IF^2 = \frac{p^4}{q^4}CI^2$.

But the radius of curvature at A, according to the determination of mathematicians, is $R = \frac{q}{p}\,\overline{q^2 - CG^2 + \frac{p^2}{q^2}CG^2}\,\Big|^{\frac{3}{2}}$, and in like manner, at B, it is $r = \frac{q}{p}\,\overline{q^2 - CI^2 + \frac{p^2}{q^2}CI^2}\,\Big|^{\frac{3}{2}}$: If we put the sine of the angle ADG, or of the lati-

* See Fig. 4, plate I.

tude at A=S, the sine of the angle BFI, or of the latitude at B=s, radius being supposed Unity, we shall have $s.\frac{p}{q}\sqrt{q^2 - CG^2 + \frac{p^2}{q^2}CG^2} = \sqrt{\frac{p^2}{q^2} \times \overline{q^2 - CG^2}}$; and $s.\frac{p}{q}\sqrt{q^2 - CI + \frac{p^2}{q^2}CI^2} = \sqrt{\frac{p^2}{q^2}\overline{q^2 - CI^2}}$; whence $CG^2 = \frac{q^2 - s^2 q^2}{1 - s^2 + \frac{s^2 p^2}{q^2}}$, and $CI^2 = \frac{q^2 - s^2 q^2}{1 - s^2 + \frac{s^2 p^2}{q^2}}$; also the radius of curvature will become $R = \frac{q p^2}{\overline{1 - s^2 + \frac{s^2 p^2}{q^4}}\big|^{\frac{3}{2}}}$; and $r = \frac{q p^2}{\overline{1 - s^2 + \frac{s^2 p^2}{q^2}}\big|^{\frac{3}{2}}}$. From which we obtain this equation $R \times \overline{1 - s^2 + \frac{s^2 p^2}{q^2}}\big|^{\frac{3}{2}} = r \times \overline{1 - s^2 + \frac{s^2 p^2}{q^2}}\big|^{\frac{3}{2}}$; from which it is evident, that the radius of curvature, or the measure of a degree, which is always in a given ratio to it, is reciprocally proportional to the quantity $\overline{1 - s^2 + \frac{s^2 p^2}{q^2}}\big|^{\frac{3}{2}}$; now when $\frac{p^2}{q^2}$ is less than Unity, or the equatorial exceeds the polar diameter, the terms $-s^2 + \frac{s^2 p^2}{q^2}$, are negative, and the whole expression diminishes in value, as s, or the sine of the latitude increases; that is, when the equatorial exceeds the polar diameter, a degree of the meridian increases, in a ratio depending on the sine of the latitude, as determined in the foregoing expression, and *vice versa*.

When $p=q$, or the equatorial and polar diameters are equal, then R=r, or the radius of curvature, or the degree of the meridian, is every where the same.

As to the actual proportion of these diameters, according to the measures of a degree, in any two latitudes, it must be determined from the resolution of the value of p, and q, in the equation $R \times \overline{1 - s^2 + \frac{s^2 p^2}{q^2}}|^{\frac{3}{4}} = r \times \overline{1 - s^2 + \frac{s^2 p^2}{q^4}}|^{\frac{3}{2}}$, which I leave to the analyst. My object has been principally to show, by a mathematical process, similar to what mathematicians have instituted for the solution of this problem, the necessary connection, and dependence, between the measures of degrees, in different latitudes of the earth, and the proportion of its axis, and equatorial diameter. Many other inferences might be deduced from the foregoing algebraic equation, involving these relations; but I have already done enough, to prove, that mathematicians have been correct in their ideas respecting the species of figure which must result from the inequality of the degrees of the meridian, near the equator and pole; and that those philosophers, who have embraced contrary notions, have been led into them, from specious resemblances, in the properties of mathematical figures, and a want of that comprehension of the more profound principles, which is essential in the investigation of truth, in difficult and abstruse inquiries of geometry.

No. IX.

OBSERVATIONS

On the Duplication of the Cube, and the Trisection of an Angle.

BY COL. JARED MANSFIELD,

SURVEYOR-GENERAL OF THE UNITED STATES.

IN the memoirs of the American Academy of Arts and Sciences, Vol. II. are two papers (No. 1 and 2) by James Winthrop, Esq. which from the importance of their subjects, cannot fail to excite the attention of the mathematical reader. In the first of those papers, the author proposes to solve the ancient and difficult problem of the *duplication of the cube*, or of finding, geometrically, two mean proportionals between any two extremes of a geometric series. This problem, in arithmetic, amounts only to the extraction of the cube root, and may very easily be solved by numbers, or logarithms. A solution, however, by the strict principles of geometry, is not so easily effected, and by no means do I apprehend that any propositions of Euclid, or of a right line and circle, are sufficient for this purpose. Newton and others, who have used a circle, have either produced a mechanical solution of this problem, or have introduced principles of the higher geometry. Mr. Winthrop appears to be the only person who has ever attempted its solution by right lines, or merely by the principles of common geometry. His construction is as follows.

* "Let ACE, ECD, and DCB be equal angles of any magnitude, and let AC and BC be the extremes given. Draw AB a right line crossing EC and DC in the points E and D; then will AEC=EDC+DCE, and for the same reason CBD=CDE—DCE. Wherefore make BDF=DCE and AEG=DCE, and we shall have three similar triangles FCD, DCE and ECG, and their sides are necessarily proportional; and the lines CF, CD, CE and CG form a series of four continued proportionals; for CD is the hypothenuse of the first triangle, and the base of the second; and is therefore a mean between CF and CE. In like manner CE is a mean between CD and CG. But the extremes CF and CG are shorter than CB and CA. Having therefore by this process ascertained the method of finding easily four continued proportionals by beginning with the mean terms; if we invert the process, and begin with the extremes, and make the angles EAI and DBK each equal to DCE, we shall have BK parallel to FD, and AI parallel to EG, *and therefore KI parallel to DE.* Therefore, the triangles CBK, CKI, and CIA are similar to CDE; and by reason of position, CK and CI are the mean proportionals sought." Thus far it appeared necessary to transcribe Mr. Winthrop's solution of this problem. The demonstration appears faultless until we come to the words, *and therefore KI parallel to DE.* From what premises this inference is drawn, is not easily conceived. It certainly cannot be justified by any principles antecedently expressed; for the parallelism of BK to FD, and of AI to EG contains no relation, whereby the parallelism of KI to DE may be inferred, and unless some other principles were taken into consideration, it is evident, that the author has fallen into a paralogism.

But that KI is not parallel to DE, except when the antecedents and consequents of the proportionals, or the two extremes are equal, may be easily proved; for which purpose make the angle EGH=FDB, and from H draw HK, then will HK be parallel to ED, and the

* See Fig. 1, plate 1.

Plate 1.

Fig. 1.

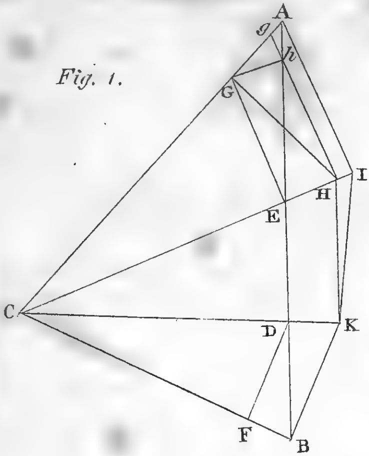


Fig. 2

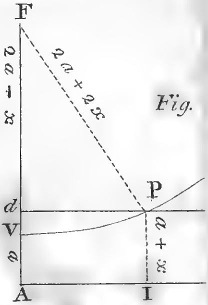


Fig. 3.

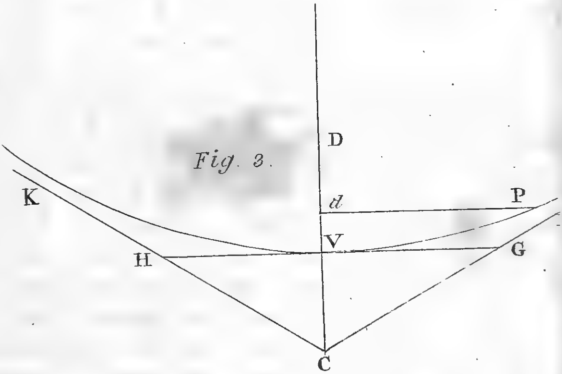


Fig. 4.

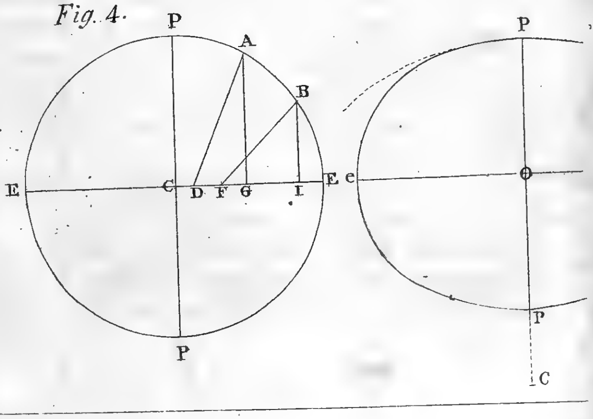


Plate 1.

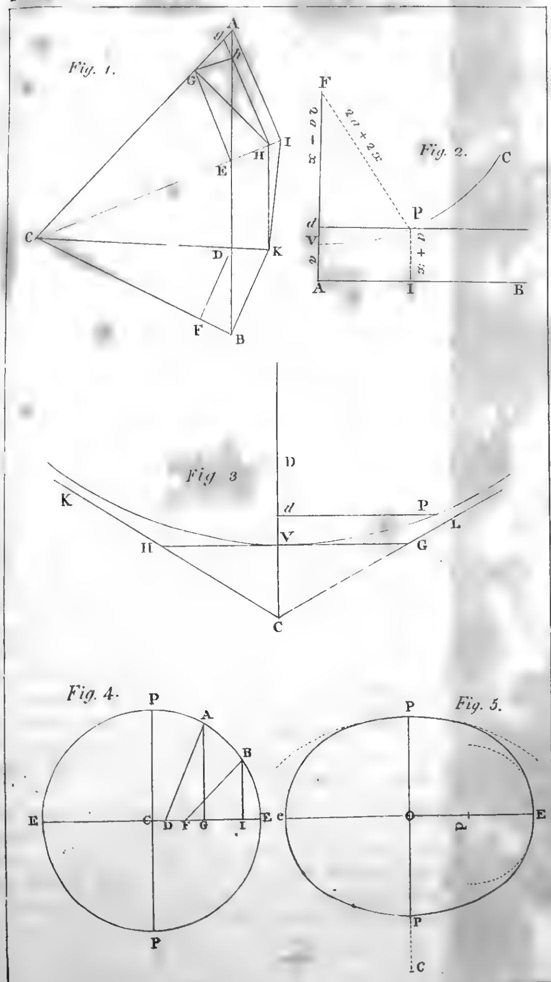
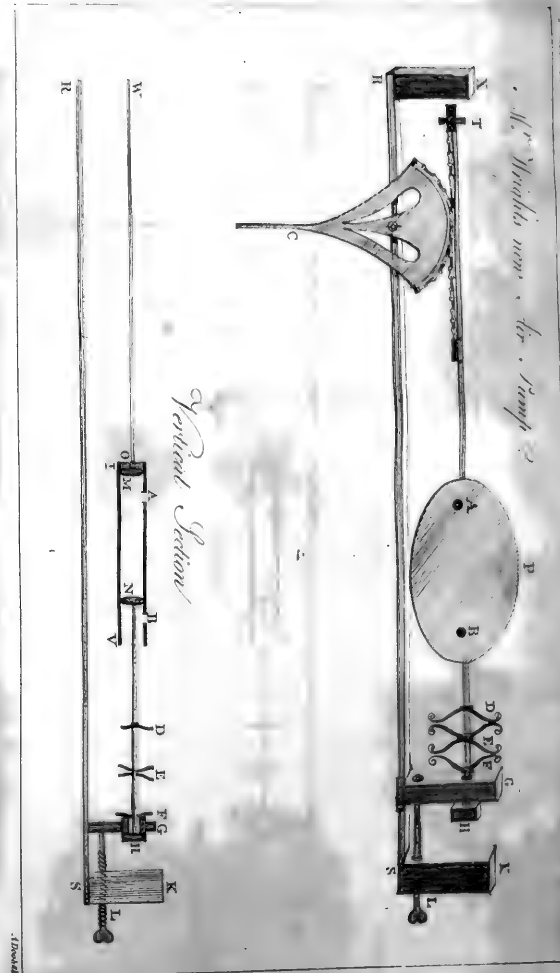


Plate 2.



point H will not coincide with I; for CF : CE : : CD : CG by similar triangles, also CD : CG : : CB : CH, and by division CF : CE : : FB : EH; but CF : FB : : CD : DK by construction; and consequently CD : DK : : CE : EH; whence by (Euc. 2. 6.) KH is parallel to DE. Draw Gh, making the angle EGh equal to the angle GEH, then will the triangle EGh, be similar and equal to the triangle GEH, and the line Hhg passing through the point h, will be parallel to EG; (Euc. 39. 1.) whence the series of parallels to FD, DE, EG, commencing at B, will terminate at the point g. Now if, according to the conditions of the problem, the terms of the proportionals be in a ratio, *minoris aut majoris inequalitatis*, or any otherwise to each other, than in a ratio of equality, the point g will not coincide with A, the extremity of the given line CA. For when CG is greater than CE, then the angle CEG is greater than the angle CGE, and GEH (EGh) the supplement of CEG is less than AGE the supplement of CGE, by the angle AGh; also Eh is less than EA by the line Ah subtending the angle AGh: but Eh : EA : : Gg : GA : : EH : EI, and therefore Gg is less than GA, and EH is less than EI. In the same manner, it may be proved that when CG is less than CE, Gg and EH are respectively greater than GA and EI; as therefore in no condition of the problem, does the point H coincide with the point I (for we consider its conditions to vanish, when the extreme proportionals are equal) and as KH has been proved to be parallel to ED, it is manifest that IK cannot be parallel to ED, and that the four proportionals made by similar triangles commencing with CB, are BC, CK, CH, and Cg. This last term not being equal to CA the given extreme, it is evident that this process by similar triangles fails to produce a just solution of the problem.

The same conclusions might have been deduced from other principles, which in their application, would have illustrated something of that relation and harmony between algebraic and geometrical quantities, which constitute one of the most beautiful theories of the mathematics, and from which the laws of geometrical constructions are derived; but this would lead to an extensive field of speculative science, not much frequented even by mathematicians. I would only observe, that geometricians have, long since, demonstrated, generally, the impossibility of solving geometrical problems of the second degree, or order, by any lines of the first order, since these cannot be so combined, as to involve the more complicated conditions and relations, necessarily implied in such problems.

The other problem, which is the subject of Mr. Winthrop's second paper, is that of the trisection of an angle, to which though equally capable of a solution by right lines, as that of the duplication of the cube, a dissimilar one has been given from the consideration of lines of a superior order, in a manner consonant to the strict principles of geometrical constructions, and which appears to be not less novel than ingenious. The author, however, has omitted to investigate the nature and specific properties of the curve, called by him, the *trisecting curve;* but it is easily shown, that it is no other than the common hyperbola: For, using his scheme, suppose VC,* the curve, AB the directrix, V the vertex, P any point in the curve; from P, draw Pd perpendicular to FV; and VA, PI perpendicular to the directrix AB; draw the line FP from the focus F to the point P; put $VA = a$, $Vd = x$, then $PI = a + x$, $FP = 2a + 2x$, and $Fd = 2a - x$; let $Pd = y$. Now in the right-angled triangle PdF, $Pd^2\ (y^2) = FP^2 - Fd^2\ (\overline{2a + 2x}^2 - \overline{2a - x}^2) = 12ax + 3x^2$; or $y = \sqrt{12ax + 3x^2}$. This equation is that of the common hyperbola, whose axes have a given ratio commensurable in power, and therefore is very easily constructed in the following manner.

From a given point C, in a right line CD, draw two right lines CK, CL, indefinitely on each side, making with CD an angle of 60°, or with one another, an angle of 120°: Set off from C, the distance $CV = 2a$; then between the two assymptotes CK, CL, and through the vertex V, construct an hyperbola, and this will be the curve required, or what is called by Mr. Winthrop, the trisecting curve.

* See Fig. 2, Plate 1.

For from V, erect the perpendiculars VG, VH; then the angles HCV, VCG, being each equal to 60°; HC, or CG, will be equal to $2\,CV = 4\,a$, and $HV^2 = 16\,a^2 - 4\,a^2 = 12\,a^2$; but by conics, $CV^2\,(4\,a^2) : HV^2\,(12\,a^2) :: \overline{2\,CV + Vd} \times Vd\ (\overline{4\,a + x} \times x) : dP^2$; putting therefore dP, the ordinate of the curve, as usual, equal to y, we shall have $y^2 = 12\,a\,x + 3\,x^2$ for the equation showing the relation of the ordinates and abscissas of this curve, which is the same as that above determined for the *trisecting curve;* consequently, this is an hyperbola, whose assymptotes are inclined in an angle of 120 degrees, and whose axes are $4\,a$, $4\,a\sqrt{3}$, respectively.

October 2, 1809.

No. X.

A STATEMENT

Of the Quantity of Rain which falls, on different Days of the Moon.

BY JEREMIAH DAY,
PROFESSOR OF MATHEMATICS AND NATURAL PHILOSOPHY IN YALE-COLLEGE.

THE influence of the Moon upon the various bodies on the earth, is a subject of general observation. The swelling of the ocean has long been ascribed to this cause. There is also a very prevalent, though vague apprehension, that there is a connection between the vicissitudes of the moon, and the growth of vegetables, the progress of diseases, the changes of the atmosphere, and other important phenomena. It is desirable that so current an opinion should be brought to the test of accurate observation. Should it prove to be well founded, it might aid us in predicting some of those changes in the atmosphere, and in the bodies around us, with which our daily concerns are intimately connected. To do justice to this subject, in all its extent, would require very numerous and diversified courses of experiments. For the purpose of ascertaining a single point, a calculation has been made on a series of observations, during the years 1804, 5, 6 and 7, on the quantity of rain which fell in New-Haven, in different periods of the moon.

The rain has been caught in a cylindrical vessel, ten inches in diameter, and about twenty inches deep. It is placed ten or twelve feet from the surface of the ground. The water, directly after it has fallen, is poured out, and measured in a tube one inch in diameter. In this way, as the area of the large cylinder is an hundred times as great as that of the small one, the depth of the water may be determined, to the thousandth part of an inch.

The snow is first melted, and then measured in the same manner as the rain. This method is tolerably accurate, except in some few cases of violent *wind.* In these instances, the best expedient seems to be, to form an estimate of the average depth of snow on the ground.

The quantity of water collected, whether from rain or snow, is entered in a column against the day of the month: and in an adjoining column, is noted the age of the moon. The following table gives a view of the whole quantities collected, on different days of the moon, during forty-eight lunations; a period a little short of four years.

	1804	1805	1806	1807	4 years.
	inches	*in.*	*in.*	*in.*	*in.*
7th day before the new Moon	.94	1.92	.22	4.94	8.02
6th	.61	3.88	1.80	1.11	7.40
5th	.42	2.70	.85	1.17	5.14
4th	1.	1.23	.15	1.25	3.63
3d	1.30	.61	.94	0	2.85
2d	.70	.48	.11	.36	1.65
1st	.12	.25	.70	1.67	2.74
NEW MOON.	0	2.10	1.27	1.46	4.83
1st after the new Moon	0	1.53	.89	.75	3.17
2d	1.38	1.10	1.08	.44	4.00
3d	.46	.25	2.11	.65	3.47
4th	.05	1.52	.72	1.17	3.46
5th	.86	.82	.78	.22	2.68
6th	4.36	1.20	.68	2.24	8.48
7th	1.63	1.73	1.39	4.06	8.81
7th before the full	5.48	2.14	.72	1.08	9.42
6th	0	3.14	.13	1.02	4.29
5th	0	1.89	2.49	.54	4.92
4th	1.05	2.59	2.36	1.72	7.72
3d	2.44	.55	.60	.43	4.02
2d	3.45	.96	1.24	1.09	6.74
1st	1.63	.97	2.01	2.50	7.11
FULL MOON.	3.38	.67	2.47	0	6.52
1st after the full	.66	.55	1.17	3.11	5.49
2d	3.16	1.14	2.44	.59	7.33
3d	1.10	1.58	1.86	3.02	7.56
4th	.33	.91	1.74	2.06	5.04
5th	1.15	1.58	2.07	.88	5.68
6th	3.39	.94	2.51	1.61	8.45
7th	0	.35	0	1.37	1.72

From this table it appears, that, if a comparison be made between the quantity of water collected at the New Moon, the Full, and the Quarters, the least portion has fallen at the New Moon ; and the greatest at the Quarters. The exact proportion will vary a little, according as the comparison is made between one, two, three, or more days, at each of these periods. If, in each lunation, only one day be taken at the New Moon, one at the Full, and one at the Quarters, the numbers will be 4.83, 6.52, 7.02. But if the average of several days be taken, they will stand as in the following table.

	One day.	*Average of 2 days.*	*Average of 3 days.*	*Average of 4 days.*
New Moon	4.83	3.89	3.58	3.39
Full	6.52	6.41	6.37	6.54
Quarters	7.02	7.03	7.02	7.06

To derive any established principle from results of this kind, it is necessary that the observations should be continued for a great length of time. Till there is opportunity for this to be done, the above may possibly serve as hints towards a more thorough investigation of the subject. With this view they are submitted.

No. XI.

DESCRIPTION OF AN AIR-PUMP.

Invented by ELIZUR WRIGHT, *Esq. Feb.* 1803.

P IS the pump plate. *IV* the pump barrel, which lies in a horizontal position, underneath the pump plate, and nearly in contact with it. *A*, and *B*, two ducts leading from the pump plate into the barrel. *WM*, a solid piston, without a valve, moving air tight in the leathern collar *O*. *T*, a stirrup, designed to keep the piston rod steady. *NH*, is a short piston, made like the former, and acted upon by the spring *D*, which is firmly fixed to the piston rod, and by the springs *E*, *F*, through which the rod passes, and is made to slide backward and forward. *G*, a slide, which serves the triple purpose of straining the springs *D*, *E*, *F*, by the screw *L*, that they may act in the first instance with a considerable force on the short piston *NH;* secondly, of keeping the piston rod steady; and thirdly, of preventing the piston from moving too far in the barrel, by means of its being met by the bolthead *H*, at the end of the rod. *C*, the arch which turns on a pin in the bar *RS*, lying underneath the barrel, and works the pump by means of a chain.

The manner in which the pump is worked is this. Suppose the short piston to be in the situation *N*, so as to cut off a communication between the barrel and external air, and the piston *WM*, in contact with it. It now moves back towards *T*, till it has passed the duct

A, when it is stopped by the shoulder *X*. In its progress, a vacuum is formed in the barrel, until it arrives at *A*, and opens a communication between the barrel and receiver, when the air, by its elastic force, rushes into the barrel and fills it. All the back space between the collar *O* and the piston *M*, both in its advance and recess, is to be considered as making a part of the capacity of the receiver. But to speak more accurately, it is only the space *OA* which is a *real addition* to the capacity of the receiver; the space *AM*, between the duct and the piston, whilst it moves forward towards *B*, being only a temporary dilatation of the capacity and the small vacuity between the collar and the piston, after it has passed the duct *A* in moving backward, being a temporary contraction of it: In both cases it is restored to its original extent, on the return of the piston. Having attained to its limit in moving back, the piston now proceeds forward, and after it has passed by the duct *A*, intercepts the communication between the receiver and barrel, and drives before it the air contained in the barrel, together with the short piston *N*, until it is stopped by the shoulder *K*, at the end of the bar *RS*, at the instant that it arrives against the middle of the duct *B*, at which the air is all forced out. The two pistons now form one air-tight stopper, that completely closes the orifice *B*, and prevents any communication of the receiver and barrel with the external air. Now the piston *WM*, is drawn back towards *T*, and the short piston *NH*, by the force of the springs *D*, *E*, *F*, follows in close contact with it, and thus continues to interpose a barrier between the barrel and external air, until it is stopped by the meeting of the bolthead *H* with the slide *G*, after having passed the duct *B*, and having arrived at the situation *N*, where the description began.

When the pump is intended to exhaust, the receiver must be placed over the duct *A*, leaving the duct *B* open to the external air; but when it is designed to condense, nothing more is necessary than to shift the situation of the receiver on the plate, placing it over the duct *B*, and leaving the duct *A* open to the external air.

No. XII.

A BRIEF ACCOUNT

Of a Trial at Law, in which the influence of Water, raised by a Mill-Dam, on the health of the inhabitants in the neighborhood, was considered.

BY THE HON. DAVID DAGGETT, ESQ.

BEFORE the Superior Court, held at Litchfield, on the fourth Tuesday of January, 1800, was tried an action of trespass, instituted by Joseph Ruggles, of New-Milford, against Elijah Boardman, and others, inhabitants of New-Milford.

The claim on the part of the plaintiff was, that the defendants, in January, 1799, destroyed a part of his mill-dam, erected across the Housatonic river, and nearly opposite the most compact part of the town. The defendants acknowledged that they had injured the dam in manner as alledged, and justified, on the ground, that the dam was a public nuisance, in that it was the cause of a distressing sickness, which had for several years visited New-Milford. It was agreed, that a dam had stood at or near the place of the present dam, for about sixty years past; and that the dam complained of, had been by the plaintiff, in July and August, 1796, raised about ten inches. It was also agreed, that a bilious remitting fever, and the fever and ague, had raged with great virulence, in the vicinity of this dam, in the years 1796--7--

8 and 9. The great question therefore, in the case, was, whether the raising of the dam in 1796 was the *sine qua non* of the disease? A variety of testimony was produced by the parties, tending to convince the court and jury of the truth of the affirmative and negative of this question. It was proved, that in each of the years above mentioned, an unusual sickness had prevailed;—that the whole number afflicted with the bilious fever was about 300;—that this fever commonly began in July, and ceased in October;—that the fever and ague had also been prevalent in the period aforesaid, but was not confined to place or season. It was also proved, that there were upwards of fifty acres of low marshy ground, on the west side of the river, opposite the town;—that there was, in July and August, much stagnant water in and about those marshes; and it was contended, (though the fact was doubtful,) that the waters in and about those sunken places, were materially affected by the raising of the dam. To prove that this state of the water, &c. might, and probably would produce the fever, the opinion of physicians, and the existence of similar facts in other places, were resorted to.

It was generally agreed by the medical gentlemen, that the bilious remitting fever, and fever and ague, of our country, are produced by marsh effluvia;—that this effluvia is caused by animal and vegetable putrefaction;—that the action of the sun on vegetables or animals, upon the receding of waters from them, frequently causes this putrefaction; and that the months of July and August, are seasons peculiarly favorable for the production of this effluvia, and its operation upon the human constitution. It was also agreed, that water, though stagnant, does not become dangerous, till it is so fetid as to offend the senses; and that while vegetables and animals are covered with running water, they are innoxious. Of the physicians who had viewed this dam, and the mill-pond made thereby, with the circumstances and situation of the town, some were of the opinion that it was the cause of the sickness, while others doubted or disbelieved it. It was proved, that the raising of the waters by mill-dams, in Salisbury, Colebrook, Roxbury, and in various places in the states of Massachusetts, Vermont, New-

York, and Pennsylvania, had been followed with fevers of the same type with that at New-Milford. It was testified by a respectable physician, that he had visited a family in Kent, living on one of the highest hills, and that several persons in the house were severely afflicted with a bilious fever;—that on examination, he discovered a small pond, nearly dry, in which there was a great quantity of dead fish, producing a very loathsome stench;—that the pond was speedily covered with fresh earth, and health was restored.

It was contended by the plaintiff, that raising the dam would not be injurious, unless thereby more ground was overflowed from which effluvia would arise; and this was denied, since the water was now kept within the well defined banks of the river;—that the situation of the town was favorable to disease, being circumscribed by high hills, and consequently subjected to a bad state of air; and that there were causes sufficient, without resorting to the dam to account for the fever. It was proved, that in the year 1796, as early as the 20th of July, there were many cases of the bilious fever, strongly marked; and that, at that time, the dam was not raised or altered from its usual height;—that the same fever had existed in many preceding years, from 1782;—that in 1799, after the destruction of the dam complained of, and while it stood with the water at its ancient level, the same fever raged, though with less malignancy, and in situations more remote from the mill-pond. These were urged as sufficient to encounter the presumption arising from the facts previously stated.

It was also proved, that in 1757, a malignant fever, (as it was then denominated,) raged, to the destruction of about forty inhabitants;—that in 1777, the dysentery prevailed, said to have been brought from the army, and that the fever and ague had always been a disease of New-Milford;—that the towns through which the Housatonic river runs, have been frequently visited with bilious fevers, and that too where no mill-dams could be resorted to as the causes.

The physicians concurred in opinion, that persons are seldom attacked with this fever more than once during an epidemic, but that the fever and ague frequently visits the patient in the spring or summer following. They also agreed, unanimously, that from 1793 or 4, fevers have been more frequent and malignant than in any preceding years, excepting that in the last season there appeared an abatement in the number of cases and violence of the disease.

It was proved, that the same disease with the one under consideration, had prevailed in many places, in this and the states of New-York and Massachusetts, within the last five years, where no mill-dams or ponds could have operated—on the most elevated hills, and in situations heretofore deemed the most healthy;—that in Great-Barrington, and West-Stockbridge, the disease appeared remote from the ponds, while the people in the vicinity of them enjoyed usual health. A respectable physician, from Sheffield, gave an account of a very distressing fever, which had prevailed there since 1795.—That a mill-dam was erected in 1787, to which it was by many ascribed; yet he declared, that from 1787 to 1795, great health prevailed, though the dam, during that period, was as high as it had been since. He also said, that during the spring of 1799, the dam was lowered, and that the disease, the summer following, was much more mild.

It was admitted, that the exposing of vegetables or animals, or other substances capable of being reduced to sudden putrefaction, to the sun, by drawing off water, draining ponds, or clearing up low grounds, tended to produce disease: but certainty, or even connection, as to particular instances in which this consequence had followed, seemed scarcely attainable.

It was obvious to all the hearers of this trial, that the more proof, the more doubt, and that the question grew perplexed by investigation. And so fully were the court and jury impressed with this idea, that they decided in favor of the owner of the dam, and gave damages accordingly; saying that they could not find it proved a nuisance.

New-Haven, March 12, 1800.

No. XIII.

ON THE DECOMPOSITION OF WHITE LEAD PAINT.

To Mr. BENJAMIN SILLIMAN, *Secretary of the Connecticut Academy of Arts and Sciences.*

SIR,

IT is well known, that a white paint, formed by mixing oil, and usually vegetable oil, with the white oxyd of lead, is very expensive, and not very durable. Within a few years after this paint is laid upon a building, it is observed that the oil has been separated from the lead, and the latter may be rubbed off with the hand, being reduced to a state in which it is easily pulverized. It is observable also, that the like paint on inside work, not exposed to water, is not liable to the same change. From these facts, it is probable that the oil, when exposed to water, undergoes a slow decomposition.

Oil is proved, by chemical analysis, to be composed of carbon, or pure charcoal, and hydrogene, or the base of inflammable air, in the proportion of nearly four parts of the former, with one of the latter. Now carbon has a very strong affinity for oxygene, one of the constituent elements of water. Is it not probable that the decomposition of the oil of paints is owing to that affinity—the carbon of the oil combining with the oxygene of water, and the hydrogene of the oil, being set free, escaping in the form of gas? If so, the art of rendering the paint durable will consist in fixing the oil, or preventing this decomposition. This is undoubtedly a great desideratum in the arts. In the course of my scanty reading on subjects of this kind, I have found nothing satisfactory. The experiments of M. de Morveau, as related in a paper communicated to the Academy of Dijon, of which an extract is found in the Encyclopedia, were evidently made before the date of the new Chemistry. It is believed that the causes of the changes which paints undergo, and which he ascribes to phlogistic vapors, are now better understood than when he wrote; and it is desirable that the attention of the chemist, as well as the artist, may be invited to the subject.

If the funds of the Academy would permit, it might be well to offer a premium for the discovery of a substance which should fix the oil in white paints, without changing their color.

I am, Sir, respectfully, your obedient servant,

N. WEBSTER, JUN.

New-Haven, Oct. 30, 1804.

No. XIV.

AN OBSERVATION

Of the Auroral Appearance in the Evening of the first day of August 1783, *at Durham.*

BY THE LATE REV. ELIZUR GOODRICH, D.D.

I FIRST observed this appearance at viii. 56. at which time a zone of auroral light extended almost from the western to the eastern horizon. I was observing the heavens not ten minutes before, and then saw nothing of it. I am informed it arose suddenly from the north-western part of the heavens, and with a swift motion coruscated to the eastern. When I first observed it, it pointed to the western part of the horizon, at about N. W. by W. and to the eastern at a little south of east, though it was not clearly to be discerned on either horizon. In the western quarter, there was a beautiful profusion of clear and bright light, almost sufficient to conceal the stars under those of the second magnitude; this rose almost to the meridian, where the light grew fainter, and went on decreasing toward the east. In the western part, the light was so great and strong, and so entirely covering the heavens, that particular streaks or coruscations could be distinguished only in the outer borders of the zone: In the eastern, they might be discerned distinctly through the whole breadth. The zone did not appear in the arch of either a great or parallel circle in the heavens, but irregular between both, its height being out of the proportion of either, and its casps toward the horizon on both sides, especially the western, declines much more northerly than regularity would admit; besides several breaks seemed to appear in the zone at times, which nevertheless were immediately filled up. The breadth of the zone was various in different parts of it, and in its successive motion southward, which at first was more rapid, till it become stationary, and then moved northward, till the whole appearance evanished.

The following observations were made during the appearance.

viii. 56.—Zone of auroral light extended almost across the heavens; rising from about N. W. by W. and descending about E. by S.—The southernmost or last bright star in the tail of *ursa major*, in the northern limb of the zone, where its breadth was equal to a third part of the distance between that star and the bright star of the crown.—Lyra, in the middle of the zone, where the breadth of the zone was equal to the third part of the distance between Lyra and Aquila.—The whole zone north of the stars in *Draco*, vulgarly called the diamond.—Brightest light in the western part; more faint in the eastern.

ix. 6.—Zone of auroral light partly evanishing in the east.—The whole zone south of Lyra—western part very bright—its southern limb touches the northern stars of the crown—its breadth nearly as above.

ix. 10.—Bright star of the crown in the middle of the zone, where the appearance is very bright and luminous, but decreaseth toward the meridian; eastward of which the whole appearance is evanished.

ix. 15.—The appearance stationary in the crown—bright westward of it, and extending about half way to the horizon—breadth not so great as at first—from Lyra half way of the crown almost wholly evanished.

ix. 16.—Western bright appearance continues stationary.—A new coruscation or stream of faint auroral light, of an equal breadth of about one degree, passing through the middle of the crown, a little north of Arcturus, and its northern limb just touching the *diamond* in *Draco*, extended to the eastern horizon, descending considerably south of east.

ix. 25.—Appearance, for some time stationary, is now moved about one degree north of the diamond, and its southern border near the northernmost stars in the crown.

ix. 28.—Bright appearance in the west evanishing.—Small coruscation evanishing in the middle; continued in the east and west.

ix. 30.—Whole appearance continues to evanish in the west.

ix. 33.—Bright light near gone.—The smaller coruscation distinctly renewed instantaneously, and nearly in a great circle from the eastern to the western horizon, passing north of the northernmost stars of the crown—north of Arcturus—south of Lyra—north of Draco.

ix. 34.—Evanishing at the eastern horizon.

ix. 35.—Evanished to *Draco*.

ix. 36.— - - - - Lyra.

ix. 37.— - - - - - the Crown.

ix. 38.—Wholly evanished.

ix. 40.—Small coruscations in the east.

ix. 45.—Faint coruscations in the west, through the tail of the Great Bear up to the Galaxy.

ix. 57.—Auroral light very faint.

x.—No auroral light to be discerned.

A faint bank of auroral light in the north during the whole, which sometimes ascended to about 30 degrees.

No. XV.

AN ACCOUNT OF THE METEOR,

Which burst over Weston in Connecticut, in December 1807, and of the falling of Stones on that occasion.

By PROFESSORS SILLIMAN and KINGSLEY.

WITH A CHEMICAL ANALYSIS OF THE STONES,

By PROFESSOR SILLIMAN.*

ON the 14th of December, 1807, about half past 6 o'clock, A. M. a meteor was seen moving through the atmosphere, with very great velocity, and was heard to explode over the town of Weston, in Connecticut,

* Note....The following account of the facts which attended the falling of stones from the atmosphere, was first published, *in substance*, in the Connecticut Herald, and, subsequently, in many newspapers, and in several literary and philosophical Journals. A revised account, together with the details of the analysis, was afterwards communicated to the Philosophical Society of Philadelphia, and has been published in their transactions. No communication was made to the Connecticut Academy, because they did not then contemplate publishing any thing *immediately*, and the public curiosity was so much alive on a subject which, in this country, was altogether novel, that there was no room for delay.

But, in consequence of the strong local interest which is felt in Connecticut, as the scene of the extraordinary event alluded to, the Academy have thought proper to direct the republication of these papers, that they may be preserved and diffused in Connecticut; disclaiming at the same time any right to them as original communications.

about 25 miles west of New-Haven. Nathan Wheeler, Esq. of Weston, one of the justices of the court of common pleas for the county of Fairfield, a gentleman of great respectability, and of undoubted veracity, who seems to have been entirely uninfluenced by fear or imagination, was passing at the time through an enclosure adjoining his house, and had an opportunity of witnessing the whole phenomenon. From him the account of the appearance, progress, and explosion of the meteor, is principally derived. The morning was somewhat cloudy. The clouds were dispersed in unequal masses, being in some places thick and opaque, and in others fleecy and partially transparent. Numerous spots of unclouded sky were visible, and along the northern part of the horizon a space of ten or fifteen degrees was perfectly clear. The attention of Judge Wheeler was first drawn by a sudden flash of light, which illuminated every object. Looking up he discovered in the north a globe of fire, just then passing behind the cloud, which obscured, though it did not entirely hide the meteor. In this situation its appearance was distinct, and well defined, like that of the sun seen through a mist. It rose from the north, and proceeded in a direction nearly perpendicular to the horizon, but inclining, by a very small angle, to the west, and deviating a little from the plane of a great circle, but in pretty large curves, sometimes on one side of the plane, and sometimes on the other, but never making an angle with it of more than 4 or 5 degrees. Its apparent diameter was about one half or two thirds the apparent diameter of the full moon. Its progress was not so rapid as that of common meteors and shooting stars. When it passed behind the thinner clouds, it appeared brighter than before; and, when it passed the spots of clear sky, it flashed with a vivid light, yet not so intense as the lightning in a thunder-storm, but rather like what is commonly called *heat lightning*.

Where it was not too much obscured by thick clouds, a waving conical train of paler light was seen to attend it, in length about 10 or 12 diameters of the body. In the clear sky a brisk scintillation was observed about the body of the meteor, like that of a burning firebrand carried against the wind.

It disappeared about 15 degrees short of the zenith, and about the same number of degrees west of the meridian. It did not not vanish instantaneously, but grew, pretty rapidly, fainter and fainter, as a red hot cannon ball would do, if cooling in the dark, only with much more rapidity.

There was no peculiar smell in the atmosphere, nor were any luminous masses seen to separate from the body. The whole period between its first appearance and total extinction, was estimated at about 30 seconds.

About 30 or 40 seconds after this, three loud and distinct reports, like those of a four-pounder, near at hand, were heard. They succeeded each other with as much rapidity as was consistent with distinctness, and, altogether, did not occupy three seconds. Then followed a rapid succession of reports less loud, and running into each other, so as to produce a continued rumbling, like that of a cannon ball rolling over a floor, sometimes louder, and at other times fainter: some compared it to the noise of a waggon, running rapidly down a long and stony hill; or, to a volley of musketry, protracted into what is called, in military language, a *running fire*.---- This noise continued about as long as the body was in rising, and died away apparently in the direction from which the meteor came.

The accounts of others corresponded substantially with this. Time was differently estimated by different people. Some augmented the number of loud reports, and terror and imagination seem, in various instances, to have magnified every circumstance of the phenomenon.

The only thing which seemed of any importance beyond this statement, was derived from Mr. Elihu Staples, who said, that when the meteor disappeared, there were apparently three successive efforts or leaps of the fireball, which grew more dim at every throe, and disappeared with the last.

The meteor was seen as far south as New-York; and the explosion was heard, and a tremulous motion of the earth perceived, between forty and fifty miles north of

Weston. From the various accounts which we have received of the appearance of this body at different places, we are inclined to believe, that the time between the disappearance and report, as estimated by Judge Wheeler, is too little, and that a minute is the least time which could have intervened. Taking this, therefore, for the time, and the apparent diameter of the body as only half that of the full moon, its real diameter could not be much less than 300 feet.*

We now proceed to detail the consequences which followed the explosion and apparent extinction of this luminary.

We allude to the fall of a number of masses of stone in several places, principally within the town of Weston. The places which had been well ascertained at the period of our investigation, were six. The most remote were about 9 or 10 miles distant from each other, in a line differing little from the course of the meteor. It is therefore probable that the successive masses fell in this order, the most northerly first, and the most southerly last. We think we are able to point out three principal places where stones have fallen, corresponding with the three loud cannon-like reports, and with the three leaps of the meteor, observed by Mr. Staples. There were some circumstances common to all the cases. There was in every instance, immediately after the explosions had ceased, a loud whizzing or roaring noise in the air,

* NOTE....From subsequent information it appears, that this meteor was seen in the eastern part of Connecticut, in New-Jersey, in the interior of the state of New-York, and as high up, at least, as Rutland, in Vermont.

It was stated by Professor Day, in a discourse before the Connecticut Academy, that a gentleman who was riding in Colchester in Connecticut, which is about 50 miles east of Weston, saw this meteor distinctly ; it was passing within 15 or 20 degrees of the moon, and appeared to him to be about one half as large as that luminary. It was justly remarked by Mr. Day that, if at this distance, it had this apparent diameter, its real diameter must have been 12 or 1300 feet, or, about a quarter of a mile ; but, as the apparent diameter was not taken with an instrument, but by estimation, it was not supposed that this conclusion was perfectly exact. It is evident, at least, that the meteor must have been much higher, when it exploded, than was at first supposed.

observed at all the places, and so far as was ascertained, at the moment of the fall. It excited in some the idea of a tornado; in others, of a large cannon shot in rapid motion, and it filled all with astonishment and apprehension of some impending catastrophe. In every instance, immediately after this, was heard a sudden and abrupt noise, like that of a ponderous body striking the ground in its fall. Excepting one, the stones were more or less broken. The most important circumstances of the particular cases were as follows:

I. The most northerly fall was within the limits of Huntington, on the border of Weston, about 40 or 50 rods east of the great road from Bridgeport to Newtown, in a cross road, and contiguous to the house of Mr. Merwin Burr. Mr. Burr was standing in the road, in front of his house, when the stone fell. The noise produced by its collision with a rock of granite, was very loud. Mr. Burr was within 50 feet, and immediately searched for the body, but, it being still dark, he did not find it till half an hour after. By the fall, some of it was reduced to powder, and the rest of it was broken into very small fragments, which were thrown around to the distance of 20 or 30 feet. The rock was stained at the place of contact with a deep lead colour. The largest fragment which remained did not exceed the size of a goose egg, and this Mr. Burr found to be still warm to his hand. There was reason to conclude from all the circumstances, that this stone must have weighed about twenty or twenty-five pounds.

Mr. Burr had a strong impression that another stone fell in an adjoining field, and it was confidently believed that a large mass had fallen into a neighboring swamp, but neither of these had been found. It is probable that the stone, whose fall has now been described, together with any other masses, which may have fallen at the same time, was thrown from the meteor at the first explosion.

II. The masses, projected at the second explosion, seem to have fallen principally at and in the vicinity of Mr. William Prince's in Weston, distant about five miles, in a southerly direction, from Mr. Burr's. Mr.

Prince and family were still in bed, when *they heard a noise like the fall of a very heavy body, immediately after the explosions.* They formed various unsatisfactory conjectures concerning the cause—nor did even a fresh hole made through the turf in the door-yard, about 25 feet from the house, lead to any conception of the real cause.

They had indeed formed a vague conjecture that the hole might have been made by lightning, but would probably have paid no farther attention to the circumstance, had they not heard, in the course of the day, that stones had fallen that morning in other parts of the town. This induced them, towards evening, to search the hole in the yard, where they found a stone buried in the loose earth which had fallen in upon it. It was two feet from the surface—the hole was about twelve inches in diameter, and as the earth was soft and nearly free from stones, the mass had sustained little injury, only a few small fragments having been detached by the shock. The weight of this stone was about thirty-five pounds. From the descriptions, which we have heard, it must have been a noble specimen, and men of science will not cease to deplore that so rare a treasure should have been immediately broken in pieces. All that remained unbroken of this mass, was a piece of twelve pounds weight, since purchased by Isaac Bronson, Esq. of Greenfield, with the liberal view of presenting it to some public institution.

Six days after, another mass was discovered, half a mile north-west from Mr. Prince's. The search was induced by the confident persuasion of the neighbours that they heard it fall near the spot, where it was actually found buried in the earth, weighing from seven to ten pounds. It was found by Gideon Hall and Isaac Fairchild. It was in small fragments, having fallen on a globular detached mass of gneiss rock, which it split in two, and by which it was itself shivered to pieces.

The same men informed us, that they suspected another stone had fallen in the vicinity, as the report had been distinctly heard, and could be referred to a particular region somewhat to the east. Returning to the place after an excursion of a few hours to another part of the town, we were gratified to find the conjecture verified, by the actual discovery of a mass of thirteen pounds weight, which had fallen half a mile to the north-east of Mr. Prince's. Having fallen in a ploughed field, without coming into contact with a rock, it was broken only into two principal pieces, one of which, possessing all the characters of the stone in a remarkable degree, we purchased; for it had now become an article of sale.

Two miles south-east from Mr. Prince's, at the foot of Tashowa Hill, a fifth mass fell. Its fall was distinctly heard by Mr. Ephraim Porter and his family, who live within forty rods of the place, and in full view. They saw a smoke rise from the spot, as they did also from the hill, where they are positive that another stone struck, as they heard it distinctly. At the time of the fall, having never heard of any such thing, they supposed that lightning had struck the ground, but, after three or four days, hearing of the stones which had been found in their vicinity, they were induced to search, and the result was the discovery of a mass of stone in the road, at the place where they supposed the lightning had struck. It penetrated the ground to the depth of two feet in the deepest place; the hole was about twenty inches in diameter, and its margin was coloured blue from the powder of the stone, struck off in its fall.

It was broken into fragments of moderate size, and from the best calculations might have weighed 20 or 25 pounds.

The hole exhibited marks of much violence, the turf being very much torn, and thrown about to some distance.

We searched several hours for the stone, which was heard to fall on the hill, but without success. Since that time, however, it has been discovered. It is unbroken, and exactly corresponds in appearance with the other specimens. It weighs $36\frac{1}{2}$ pounds.* It is probable that the five stones last described were all projected at the second explosion.

* It has been purchased by Mr. Gibbs, of Newport, Rhode-Island, who has thus enriched his splendid collection of minerals with the finest meteoric stone which is probably extant. This specimen abounds so much with iron, that it might almost be denominated an iron ore; some of the pieces of iron visible on the surface, are more than an inch long.

III. At the third explosion a mass of stone far exceeding the united weight of all we have hitherto described, fell in a field belonging to Mr. Elijah Seeley, and within thirty rods of his house. Mr. Seeley's is at the distance of about four miles from Mr. Prince's. Mr. Elihu Staples lives on the hill, at the bottom of which this body fell, and carefully observed the whole phenomenon.

After the last explosion, he says, a rending noise like that of a whirlwind passed along to the east of his house and immediately over his orchard, which is on the declivity of the hill. At the same instant a streak of light passed over the orchard in a large curve, and seemed to pierce the ground. A shock was felt, and a report heard like that of a heavy body falling to the earth; but no conception being entertained of the real cause, (for no one in this vicinity, with whom we conversed, appeared to have ever heard of the fall of stones from the skies) it was supposed that lightning had struck the ground. Three or four hours after the event, Mr. Seely went into his field to look after his cattle. He found that some of them had leaped into the adjoining enclosure, and all exhibited strong indications of terror. Passing on, he was struck with surprize at seeing a spot of ground which he knew to have been recently turfed over, all torn up, and the earth looking fresh, as if from recent violence. Coming to the place, he found a great mass of fragments of a strange looking stone, and immediately called for his wife, who was second on the ground.

Here were exhibited the most striking proofs of violent collision. A ridge of micaceous schistus lying nearly even with the ground, and somewhat inclining like the hill to the south-east, was shivered to pieces, to a certain extent, by the impulse of the stone, which thus received a still more oblique direction, and forced itself into the earth to the depth of three feet, tearing a hole of five feet in length and four and a half feet in breadth, and throwing large masses of turf and fragments of stone and earth to the distance of 50 and 100 feet. Had there been no meteor, no explosions, and no witnesses of the light and shock, it would have been impossible for any person contemplating the scene to doubt, that a large and heavy body had really fallen from the skies with tremendous momentum.

From the best information which we could obtain of the quantity of fragments of this last stone, compared with its specific gravity, we concluded that its weight could not have fallen much short of 200 pounds. All the stones, when first found, were friable, being easily broken between the fingers; this was especially the case, where they had been buried in the moist earth; but by exposure to the air, they gradually hardened.

This stone was all in fragments, none of which exceeded the size of a man's fist, and was rapidly dispersed by numerous visitors, who carried it away at pleasure. Indeed we found it difficult to obtain a sufficient supply of specimens of the various stones, an object, which was at length accomplished, principally by importunity and purchase.

The specimens obtained from the different places are perfectly similar. The most superficial observer would instantly pronounce them portions of a common mass. Few of the specimens weigh one pound, most of them less than half a pound, and from that to the fraction of an ounce.

The piece lately found on Tashowa Hill is the largest with which we are acquainted. Mr. Bronson's is the next in size. The largest specimen in our possession weighs six pounds, and is very perfect in its characteristic marks. Of smaller pieces we have a good collection. They possess every variety of form, which might be supposed to arise from fracture with violent force. On many of them, and chiefly on the large specimens, may be distinctly perceived portions of the external part of the meteor. It is every where covered with a thin black crust, destitute of splendor, and bounded by portions of the large irregular curve, which seems to have inclosed the meteoric mass. This curve is far from being uniform. It is sometimes depressed with concavities, such as might be produced by pressing a soft and yielding substance. The surface of the crust feels harsh, like the prepared fish skin, or shagreen. It gives sparks with the steel. There are certain portions of the stone covered with the black crust, which appear not to have formed a part of the out-side of the meteor, but to have received this coating in the interior parts, in consequence of fissures or cracks, produced probably by the intense heat, to which the body seems to have been subjected. These portions are very uneven, being full of little protuberances. The specific gravity of the stone is 3.6, water being 1. The specific gravity of different pieces varies a little; this is the mean of three.

The colour of the mass of the stone is mainly a dark ash, or, more properly, a leaden colour. It is interspersed with distinct masses, from the size of a pin's head to the diameter of one or two inches, which are almost white, resembling, in many instances, the crystals of feldt-spar in some varieties of granite. The texture of the stone is granular and coarse, resembling some pieces of grit stone. It cannot be broken by the fingers, but gives a rough and irregular fracture with the hammer, to which it readily yields. On inspecting the mass, five distinct kinds of matter may be perceived by the eye.

1. The stone is thickly interspersed with black or grey globular masses, most of them spherical, but some are oblong. Some of them are of the size of a pigeon shot, and even of a pea, but generally they are much smaller. They can be detached by any pointed iron instrument, and leave a concavity in the stone. They are not attractable by the magnet, and can be broken by the hammer. If any of them appear to be affected by the magnet, it will be found to be owing to the adherence of a portion of metallic iron.

2. Masses of yellow pyrites may be observed. Some of them are of a brilliant golden colour, and are readily distinguishable by the eye. Some are reddish and some whitish. The pyrites appear most abundant in the light colored spots, where they exhibit very numerous and brilliant points, which are very conspicuous through a lens.

3. The whole stone is interspersed with malleable iron, alloyed with nickel. These masses of malleable iron are very various in size, from mere points to the diameter of half an inch. They may be made very conspicuous by drawing a file across the stone.

4. The lead-coloured mass has been described already;

and constitutes by far the greater part of the stone. After being wet and exposed to the air, the stone becomes covered with numerous reddish spots, which do not appear in a fresh fracture, and arise manifestly from the rusting of the iron.

5. There are a few instances of matter dispersed irregularly through the stone, which are considered as intermediate between pyrites and malleable iron. They are sometimes in masses apparently crystalline, but usually irregular. They are black, and commonly destitute of splendor, but exposed by a recent fracture, they appear like a glossy superficial coating. They are sometimes attractable by the magnet, and sometimes not.

CHEMICAL EXAMINATION of the Stones which fell at Weston, (Connecticut,) Dec. 14, 1807. By B. SILLIMAN, *Professor of Chemistry in Yale College.*

THE public are already in possession of ample details concerning the fall of these bodies, and the phenomena which preceded the event.—I have made an attempt to ascertain their nature, by a series of experiments, the result of which is now communicated to the public. It will be necessary to make some observations, and to detail some experiments, upon each of the constituent parts of the stone.

I. Of the stone at large.
II. Of the pyrites.
III. Of the malleable iron.
IV. Of the black irregular masses.
V. Of the crust.
VI. Of the globular bodies.

I. *Of the stone at large.*

1.—100 grains of the stone, taken without any particular reference to the various bodies, and, containing promiscuously, portions of all of them, were pulverized in a porphyry mortar. The malleable iron resisted the pestle, so that the mass could be reduced only to a coarse powder. It was then digested for 11 hours, with a moderate lamp heat, in strong nitric acid, in a capsule of porcelain. Nitrous gas was disengaged with the usual red fumes, and, a light whitish matter appeared, dispersed through the solution, resembling gelatinous silex.

2.—The clear fluid was decanted from the insoluble residuum, all of which, except a small portion of the white floculent matter, had subsided; to separate this, the fluid was filtered, and exhibited a decidedly greenish color.

3.—The solid residuum was heated over an Argand's lamp, till it was quite dry, and then triturated for an hour, in mortars of porphyry and jasper. As the malleable iron had now been removed by the acid, the residuum was easily reduced to a fine powder, which had a brick red color, and was digested again, for an hour, with a mixture of nitric and muriatic acids, somewhat diluted, and then boiled for some time in the same fluid. This was decanted and filtered, and the residuum was washed with water till it came off tasteless; these washings were all filtered and added to the two solutions Nos. 2 and 3. The entire fluid had now a light yellow color, owing to the nitro muriatic acid present in excess.

4.—The solid residuum, together with the solid matter arrested by the filters, being ignited in a platinum crucible, became nearly white, and weighed 51,5 grains. It was fused with potash in a silver crucible, and the crucible, with its contents, was immersed in water contained in a silver bason; the resulting fluid was decomposed by muriatic acid and evaporation, and, the precipitate, after ignition in a platinum crucible, was white. There could now be no hesitation in pronouncing it to be silex, and the conclusion seemed sufficiently established, that more than half the stone consisted of this earth.*

5.—The entire solution was next examined, to discover what was the soluble part of the stone.

After the superfluous acid was saturated by ammonia, a very voluminous red precipitate appeared, which was

* Were it not for the infant state of chemistry in this country, it would be unnecessary to remark, that all the most important tests and re-agents employed in these experiments, were *absolutely pure*; for, very few of them can be obtained *pure* from the shops; the silver vessels were also perfectly pure, as were those of platinum.

oxid of iron. The fluid was filtered, and heated on a sand bath, to expel the excess of ammonia, and to precipitate any additional portion of oxid of iron which it might have suspended, but none was obtained.

6.—The precipitate being washed, collected, dried and ignited strongly, in a platinum crucible, had a dark brown colour, inclining to red, and weighed 38 grains. Six grains of this weight were allowed for what adhered to the filter, which was accurately weighed before it was used, and after it had been thoroughly dried on a heated slab of Portland stone, and the difference of weight was 6 grains.

The oxid of iron thus obtained was not in the highest state of oxidizement; for, it was *completely*, although not very *powerfully* attractable by the magnet, by which the whole of it was actually transferred from a plate of glass to a wine-glass. It ought to have been oxidized to a maximum, considering the process by which it was obtained;—possibly some adhering ammonia, and a portion of charcoal, which accidentally got into the crucible, might have abstracted a part of its oxigen, with the aid of heat, and indeed heat alone would have expelled a portion of oxigen.

7.—The fluid from which the oxid of iron had been separated, had now a greenish colour, precisely similar to what it had in No. 2. Carbonat of potash produced no precipitate, but, caustic potash threw down a pretty voluminous fleecy white precipitate. Being separated by the filter, dried, collected, and moderately heated, it became almost black; but, on being heated strongly in a platinum crucible, covered by an inverted crucible of the same metal, it became white. It weighed 13 grains. It dissolved rapidly in sulphuric acid, and afforded, by evaporation, prismatic crystals, which had an acidulous, bitter taste; the former arising from a redundancy of the sulphuric acid;—it afforded a white precipitate, with caustic potash—suffered the aqueous fusion, and became a dry mass, on a live coal. From all these considerations, it was concluded, that the 13 grains were magnesia.

These crystals of sulphat of magnesia had a very slight tinge of green, a circumstance which was, doubtless, connected with the dark appearance of the magnesia, when first heated. It shall be resumed presently.—It should be observed, that in some of the experiments with sulphuric acid on this supposed magnesia, a white matter, in small quantity, remained undissolved at the bottom of the vessel.—It could hardly be silex, and preliminary experiments led me to conclude that no lime was present.—Was it accidental, or, was there a small portion of alumine? This white matter, when heated with sulphuric acid and sulphat of potash, did not afford crystals of alum, on evaporation. I have not yet had leisure fully to decide this point, but intend to resume it. The stone has a very slight argillaceous smell, when breathed upon.

8.—The remaining solution still retained its greenish colour. Previous trials had decided, that neither copper nor iron was present in the solution. Nickel was therefore sought for, and the observations of Howard and Vauquelin, in their analyses of the stone of Benares, led me to expect it in triple combination with the ammoniacal nitrat and muriat, which had been formed in the liquor by a previous step of the process. According to the experience of Howard, I found the hidro sulphuret, and the prussiat of ammonia, the only agents among those which I tried, that would precipitate the nickel. The prussiat of ammonia gave a white precipitate, inclining to purple; the hidro sulphuret of ammonia, a voluminous black precipitate. The hidro sulphuret was used, and the precipitate was separated by the filter; the filter was dried, and it was with great difficulty that about three fourths of a grain were collected; the portion adhering to the filter was estimated at a grain; that which had been collected was ignited in a platinum crucible, and became green; it was, without doubt, the oxid of nickel, and with every allowance for loss and other circumstances, the whole cannot be estimated at more than 1,5 grain. In this estimate is included a portion of nickel which adhered to the magnesia, when it was precipitated; which caused it to turn black, when first heated—which gave the sulphat of magnesia formed from it a slightly greenish tinge; and whose existence is still farther proved, by the black colour which was produced, when a solution of this salt was mixed with the hidro sulphuret of ammonia.

9.—The fluid from which the nickel had been precipitated, was now of a yellow colour, unmixed with green. Its present colour was derived from the hidro sulphuret of ammonia, and nothing could now be detected in the solution, except what had proceeded from the various re-agents employed.

There was, however, one other constituent of the stone, of whose existence the eye furnished decisive evidence, of which no account has hitherto been given, namely, the sulphur. As to the quantity of this, I can give only an estimation. Of the grounds of that estimation, as well as of the fruitless attempts which were made to collect the sulphur, I will speak presently; but for the sake of concluding this head, I will now add, that the sulphur was estimated at 1,. If this analysis be correct then, the 100 grains which were examined afforded,

Silex, - - - -	51,5
Oxid of iron, - -	38,
Magnesia, - - - -	13,
Oxid of nickel, - -	1,5
Sulphur, - - - -	1,
	105,

The excess, instead of the usual loss, proceeds, manifestly, from the oxidizement of the iron, in a considerable, but unknown proportion. I must add, that the proportions of these ingredients vary in different parts of the stone, as is manifest to the eye, and will be immediately more fully evinced. In the analyses of others, should there be found some difference of proportion, it will not therefore necessarily indicate a contradiction. The great point of the similarity of these stones to those which have fallen in other countries, and which have been analysed by Howard, Vauquelin, Klaproth, and Fourcroy, who have been my guides in this investigation, will now, in all probability, be considered as sufficiently established. Had the daily avocations of a course of public lectures allowed the necessary time, I should have attempted something like a complete analysis of each of the constituent parts of the stone. If circumstances permit, this may still be done; but, in the mean time, a few observations of perhaps some utility may be offered.

II. *Of the Pyrites.*

In the stones in our possession, very few masses of pyrites of any considerable size are to be found; and they are generally so friable, that it was only with great difficulty, and patience, that 20 grains could be collected from 200 or 300 pieces. Their powder is blackish. I digested these 20 grains for 12 hours, in muriatic acid, somewhat diluted, hoping to separate the sulphur, so as to collect it as Mr. Howard had done. But, in this I was disappointed. Only a very few minute portions of sulphur appeared; they did not, as with Mr. Howard, float, but subsided among the earthy sediment; and only enough of them was collected to decide the existence of sulphur, by their burning with the peculiar smell of that substance. During the solution, the smell of sulphuretted hidrogen gas was emitted. As the stone, or, at least, some parts of it, emits the smell of sulphur, when heated, I attempted to procure the sulphur by sublimation. A portion of the powdered stone was placed in a coated glass tube, the upper part of which was kept cold, while the coated part was ignited for an hour, but no sulphur was obtained.

I caused the gas which arose from the solution of the metallic part of the stone in the sulphuric and muriatic acids, to pass into a solution of caustic potash—only a small portion of it was absorbed; the potash became slightly hidro sulphuretted, since it precipitated the acetat of lead, black, and deposited a little sulphur upon the addition of sulphuric acid.

As I had already robbed the specimens of almost every tangible mass of pyrites, and injured them considerably, by the extraction, I was compelled to relinquish the idea of obtaining the exact proportion of the sulphur.

Mr. Howard, in the analysis of the stone of Benares, states the sulphur at 2 parts in 14 of the pyrites, or, about 15 per cent. If we may suppose these pyrites to be of the same composition, (and their physical properties correspond with Count Bournon's description,) we might deduce the proportion of sulphur from the proportion of pyrites in the stone, for, there is every reason to believe that the sulphur exists in no other part of the stone, except the pyrites, and those masses which have proceeded from their decomposition. It is impossible, however, to separate the pyrites from the other parts of the stone, so as to estimate their proportion exactly; but, they evidently do not exceed one fifteenth of the whole stone. If therefore the sulphur be estimated at 1, it is probable the estimate will not be very erroneous.

The muriatic solution of the pyrites had a greenish colour; ammonia threw down the iron in a black precipitate, becoming rapidly red, when exposed to the air. The filtered fluid gave no traces of magnesia, when examined with caustic potash; but, hidro sulphuret of ammonia gave an abundant precipitate of nickel. Hence these pyrites are composed of iron nickel and sulphur. Having saved the precipitates, I still hope to obtain the proportions of the two former.

III. *The malleable Iron.*

When the stone is pulverized, the magnet takes up, usually, more than 40. I have taken up even 50, but once only 23. This is, however, far from being all iron; there is much adhering earthy matter—some adhering pyrites, and, in short, all the principles of the stone adhere. A separate analysis of the attractable part, gives us nothing different from the results already stated, except an increase in the proportion of metallic matter, and a diminution in that of the earthy principles. The malleable iron contains nickel equally with that in the pyrites. On the other hand, a separate analysis of the unattractable part, presents no other diversity than a diminution of the metallic, and an increase of the earthy principles. I have separated a piece of malleable iron, so large, that by alternately heating and hammering, it was extended into a bar six tenths of an inch long, and one tenth thick; another mass was hammered into a plate more than half an inch in diameter. The attractable part of the stone dissolves rapidly in the strong acids; the muriatic and the sulphuric, *diluted*, give abundance of hidrogen gas, partially sulphuretted, and, nitric acid gives copious fumes of nitrous gas. In the same masses are found malleable iron—pyrites—and matter in an intermediate condition, intimately blended and adhering to each other.*

IV. *The irregular black masses.*

Some of these appear somewhat regular, like crystals of schorl, but most of them are irregular. While examining them, I found in some, appearances of pyrites in a state of decomposition. This led to a suspicion, that these masses were merely pyrites, which, by the force of heat, had been decomposed more or less completely. Accordingly, on separating a good many portions of these bodies, some were found readily---others feebly---and others not at all attractable by the magnet. But, the latter, by being heated for a few minutes, with the blow-pipe, became decidedly attractable. As a standard of comparison, some golden coloured pyrites from Peru, were heated by the blow-pipe, to expel the sulphur, and were made to pass through all the shades of colour, and degrees of magnetic attractability, corresponding with the various conditions of the black irregular masses. Little doubt could now remain, that the conjecture concerning their nature was well founded. The glossy interior coating, mentioned in the mineralogical description, appeared to be of the same nature, and to approach nearly to the state of malleable iron.

* It is a curious fact, that the two famous masses of native iron, found in Siberia and Peru, (as well as the native iron of Bohemia and Senegal,) contain nickel; no ore of iron contains nickel----the popular tradition in some of the countries mentioned, is, that *the iron fell from heaven*----the masses are large and heavy, and were found at a distance from any possible source of iron----they are cellular and cavernous, as if some earthy cement had been decomposed and washed out by time; and still, a stony matter, resembling crysolite, and extremely like the hardest parts of the meteoric stones, remains adhering to the iron. No such iron is found in iron mines, and there can now be little doubt that *these masses of native iron are really of meteoric origin;* were the large stone from Weston, in the possession of Col. Gibbs, to be exposed to the weather till the earthy cement was worn away, it would resemble the Siberian and Peruvian iron.

V. *The Crust.*

The black external crust adheres so closely to the earthy matter within, that it is not easy to separate it. Indeed, it appeared scarcely worth while to subject it to a separate analysis, since the blow-pipe sufficiently indicates the difference between it and the rest of the stone. For, on heating any small portion of the stone with the most intense flame that the blow-pipe can give, it becomes covered with a black crust similar to that of the stone. The only point then in which the crust differs from the rest of the stone is, *that it has been changed by strong ignition*, having suffered a sort of vitrification, and its metallic parts a partial oxidizement; I say, partial, for when detached, it is attractable by the magnet, and the file discovers points of malleable iron.

VI. *The globular bodies.*

These appear to be merely portions of the stone, embracing probably all its principles, which have been melted by intense heat, and, being surrounded by solid matter, have become more or less globular, like the globules of metal which appear dispersed through a flux, in a crucible, after an operation with a very high degree of heat, upon a very refractory metal.

The globular bodies in this stone, although not attractable by the magnet, readily become so by being heated with the blow-pipe.

Is the iron in them too highly oxidized to admit of attraction, and, are they partially reduced by ignition on charcoal?---Finally, is there not reason to conclude, that these meteoric stones originally presented nothing distinguishable by the eye, except pyrites, and the enveloping earthy matrix---that, by the operation of heat, the irregular black masses have been produced, by a partial decomposition of the pyrites---that, by a still more intense heat in certain parts, the pyrites have been altogether decomposed, and malleable iron produced---that the crust is produced by a mere oxigenizement and vitrification---that the difference of colour in the earthy part is owing to the unequal operation of heat, the pyrites being left, in some places, especially in the white spots, almost wholly undecomposed, and that the globular bodies have been formed by a complete fusion of certain portions, by intense ignition.

Yale College, January 14, 1808.

POSTSCRIPT----*February* 22, 1808.

IN Nicholson's Journal for October, 1806, (No. 61, p. 147,) is an abstract of a memoir by M. Laugier, taken from the 58th volume of the Annals of Chemistry, in which the author asserts the existence of a new principle in meteoric stones, viz. *chrome.* Before adverting to this subject, it will be well to point out another assertion in M. Laugier's memoir, which appears to have been incorrectly expressed.---After remarking, that all chemists who have examined meteoric stones, "have obtained similar results," he enumerates the principles which have been discovered in them, and says they are silex, iron, *manganese*, sulphur, nickel, with a few accidental traces of lime and alumine. It seems plain, that manganese has here been carelessly written instead of magnesia; for, neither Mr. Howard, nor any of the able chemists who succeeded him in the examination of meteoric stones, before M. Laugier, ever found manganese, but constantly magnesia; and as magnesia is not mentioned at all by this latter chemist, I think it is plain that magnesia is intended by him, when he writes manganese. Dismissing this for an inadvertency, we will therefore return to *chrome.*

I have carefully repeated, and somewhat varied and extended the experiments of Laugier, on the discovery of chrome in meteoric stones.

1. A strong solution of caustic potash was boiled for an hour on a portion of the stone in powder---the fluid was filtered---it had a slightly yellowish colour.

2. Nitric acid was added, somewhat in excess, in order that the potash might all be saturated.

3. Nitrat of mercury, recently formed, without heat, was added, but there was no precipitate whatever;---at this stage of the process, Laugier "threw down a red orange coloured precipitate, or chromate of mercury."

4. A small portion of the stone was now fused with pure potash, in a silver crucible, and maintained, for some time, in a red heat;---every thing soluble was then taken up by water---the fluid was filtered, and had a green colour.

5. Nitric acid was added, a little in excess, and then nitrat of mercury as before, but no precipitate ensued; these experiments were several times repeated, and with the same success.

6. Other portions of the fluid resulting from the boiling of potash upon the stone, and from its fusion upon it, and subsequent solution, were now mixed with the nitrat of mercury, without the previous addition of nitric acid. A copious yellow precipitate was thrown down---this was heated to ignition in a platinum crucible---the oxid of mercury was decomposed, and its elements expelled, and a small portion of a green oxid remained in the crucible.

In several repetitions of the process, this invariably occurred.---I had been led to suppose that this was the oxid of nickel, because the alkaline solution from which it had been obtained, gave a black precipitate with the hidro sulphuret of ammonia. Accordingly, on fusing a portion of this oxid with borax, under the blow-pipe, it produced a glass of a hyacinth red; the same fact took place with a portion of a substance known to be the oxid of nickel, which was fused with borax for the sake of comparison.

On fusing a portion of the chromat of lead, or Siberian lead ore, with borax, and afterwards with vitreous phosphoric acid, glasses, of an emerald green colour, were produced.

Hence it was concluded, that the meteoric stones of Weston do not contain chrome, but that the green oxid obtained was the oxid of nickel.

No. XVII.

ORIGIN OF MYTHOLOGY.

BY NOAH WEBSTER, JUN. ESQ.

NO subject of antiquity has more seriously engaged the attention, or confounded the ingenuity of modern historians and antiquaries, than the origin of heathen mythology. It is a field of inquiry in which conjecture has long rambled without control, imagination supplying what authentic history cannot furnish, and the toils of laborious erudition producing but a scanty harvest of truth. Yet the student who finds, in every page of the Greek and Roman classics, some deity intermeddling with human affairs, or presiding over the elements and the operations of nature; the traveller who examines the stupendous temples erected to Jupiter and Mars, to Juno and Venus, or walks over the majestic ruins of Balbec and Palmyra; and the philosopher who traces the progress of man, his customs, institutions and religious ceremonies, is solicitous to pry into the origin of that multifarious machinery of gods and goddesses, whose worship exhausted the wealth, and controlled the passions of the pagan world.

In attempting to unravel this intricate subject, we find, in history, no safe clue to guide us; for the origin of the mythological deities was in ages long anterior to the invention of letters and the art of writing. To increase the perplexity, we meet with an immense mass of fictions and traditionary tales, introduced by fancy and conjecture, which has been accumulating for almost four thousand years.

The present age has furnished two learned treatises on this subject; the "Analysis of Ancient Mythology," by Mr. Bryant, and a "Dissertation on the Mysteries of the Cabiri," by Mr. Faber. These authors, both men of erudition and celebrity, are entitled to the praise of throwing light on a very obscure subject. But not having resorted, in many instances, to the true sources of correct information, they have probably fallen into numerous mistakes.* Bryant supposes that the war of the Titans relates to the overthrow of Nimrod and his adherents, in the attempt to build Babel. Faber, on the contrary, endeavors to prove that that contest relates to the events of the deluge, and that to the same events are to be referred the mysteries of the Cabiri, or great deities of Greece, as well as the mysteries of Isis, Ceres, Mithras, Bacchus, Rhea and Adonis. He maintains that the characters in Grecian and Indian mythology, under the names of Deucalion, Ogyges, Saturn, Janus, Uranus, Cronus, Atlas, Dagon, Inachus, Phoroneus, Argus, Menu and Minyas, Taut or Thoth, Hermes, Mercury, Budha, Fohi, Woden, Bacchus, Osiris, Adonis, Hercules, Pluto, Vulcan, Brahma, Vishnou, and Seeva, all represent Noah, venerated as a prince, or worshipped with the sun as a deity.

* These gentlemen have assumed, as the basis of their etymologies, certain primitive or elementary words, found in the oriental languages, most of which they have correctly explained, but the radical sense of several of them, they have evidently mistaken. Both of them, however, have, in my opinion, misapplied a number of these elements. Faber in particular, has, if I mistake not, fallen into numerous errors. In many instances he has even made the terminating syllable of Greek and Latin words, which is almost always the article, *ος*, *us*, &c. a radical noun. An inattention to this fact has been a fruitful source of mistakes on this subject. Thus the river *Cyrus*, is the oriental *Kur*, with the article *ος*, us, added by the Greeks and Romans; *Euphrates*, is the oriental *Forat*, or *Phrat; Indus*, is *Ind* or *Sind;* Ganges, is *Ganga*, or *Gonga*. The same is the fact with most words which we receive through Greek and Roman channels, whether native words of Greece and Italy, or foreign words which their writers had occasion to use.

Bryant, on the authority of Virgil, Macrobius, Servius, Athenagoras, Pausanias and other writers, ventures to affirm that most or all the Greek and Roman deities were in fact *one*, or that they referred primarily to the sun. That the Greeks and Romans confounded their characters, is certain; but that Saturn, Jupiter, Dionusus, Apollo, Hermes, Pan, Pluto, Ceres, and most of the other deities, all originated in the worship of the sun, or had primarily the same character and functions, is extremely improbable.*

Gebelin, on the other hand, has endeavored to prove that the deities worshipped by the ancients, represented the heavenly orbs, and constellations which governed or influenced the seasons; or the seasons and physical events by which agriculture was regulated, and on which the primary ocupations of men depended for success. His explication of the offices of the deities is extremely ingenious, and in my opinion far more satisfactory, than those of any writer whose works I have seen. Yet I think his opinions susceptible of correction and material improvement; indeed, his explanation of the names of the deities, is generally erroneous.†

In the course of my philological researches, but without any particular design to investigate the Pagan mythology, I have probably discovered the true origin of some of the supposed deities of antiquity. And from the facts discovered, it appears probable, that the principal, if not the only safe guide to direct us to the real origin of a

* See Bryant's Analysis, vol. i. et passim.—Faber, vol. i. Cluver, citing the authority of Macrobius, in his Saturnalia, lib. i. ca. 17, assents to his opinion, that all the names of the gods referred to the sun, and those of the goddesses, to the moon; and adds that all of them "ad unum, verum, aeternumque Deum esse referenda."---Lib. i. 26. All history is full of testimonies to the extensive worship of the sun. Not only was this luminary the object of worship among the Persians, under the name of *Mithras*, and among the Sabeans in Chaldea and Arabia, but among the Scythian nations, the Celts and Teutones. The Massagetæ, says Herodotus, lib. i. 216, sacrificed horses to the sun, *their only deity*. But this does not prove that all the names of deities had reference to the sun.

† See his Allegories Orientales, in his Monde Primitif. vol. i. and his Histoire du Calendrier, in vol. iv.

pagan deity, is, the signification of his name, in the first or primitive language in which it was used. Whenever the original sense of the name coincides with the primitive office or most prominent features of the character, we may safely conclude that we have arrived at the origin of the deity, or the circumstance which gave him birth.

The first or oldest of the Pagan deities is said to have been *Saturn* or *Cronus*. He is represented by the ancient writers as the son of *Coelus* and *Terra*, or of *Uranus* and *Terra*, the heaven and the earth. Faber considers Saturn and Janus as the same deity, and the same as Cronus or Noah, and the sun. Bryant supposes the name composed of *sait-our*, the Olive of Orus, a deity; and *Janus*, he derives from οινας, a dove. Bochart thinks it clear that Saturn was Noah.*

Gebelin supposes Cronus or Saturn to be an allegorical personage, representing not only *time*, but the operations of agriculture. The Greek name, κρονος, he alledges to be formed from the primitive name of a horn, *keren*, *cornu*, and figuratively representing power, force, grandeur. *Saturn*, he deduces from שרי, a sower, the author of production. In this he is probably correct, but he leaves the last syllable unexplained.†

But there is no difficulty in tracing the origin of this deity. *Cronus*, a Greek word signifying a year or time in general, is a Celtic word signifying *round*, *circular*, in Welch *krun*, in Irish and Gaelic, *cruin*; a word which is most probably a compound of כר, a circuit, and *on*, the sun, the circular orb. The Irish *grian*, the sun, is probably of like origin, or the same word varied by dialect. *Cronus* then is the sun, or the annual revolution of that orb; a great circle; the measure of a year; hence a year, or time in general.

This etymology coincides with the opinion of Macro-

* Faber, vol. ii. 31.—Boch. Geog. Sac. lib. i. 1.—Bryant, vol. ii.—Hesiod's Theog.—Virg. Æn. viii. 319.

† History of Saturn, Monde Prim. vol. i. p. 38. 40. *Cronus*, and *keren*, *cornu*, a horn, are children of a common parent—both named from their *rotundity*, but they have no other relation to each other. We have the same word in *corona*, *crown*, from its figure.

bius, who informs his readers that Cronus is the sun, and the author of time, or the seasons.*

On, the oriental name of the sun, signifies also, a circle, and probably from the same source as the Celtic *ean*, *ain*, a circle, the Hebrew עין, the Ethiopic *oin*, an eye, from its roundness; also, a fountain, and in the Amharic, a grape.†

On, the sun, was worshipped in Syria and Egypt. Hence we read in scripture of Potiphera, a priest of On, that is, of the sun; of *Amon*, or *Hammon*, a title of the sun, or deity of Thebes—*cham* or *ham*, heat, and *on*, the circular orb of the sun.‡

Hence the name used in Genesis xiv. 18, עליון, *Olion*, rendered the *Most High*. Melchi-zedek is called כהן לאל עליון priest to the most high God. In a fragment of Sanchoniathon, as translated by Philo, and preserved by Eusebius, this word is explained in the same manner. Κατὰ τȣτους γίνεταί τίς Ελίουν καλουμενος ΥΨΙΣΤΟΣ. Then lived a certain *Elion*, called the *Most High*.§

This word is composed of על high, and עין *ean*, *ain*, *on*, a circle or orb; and originally was applied to the sun; and we observe this root *on*, incorporated into many words expressing the idea of a circular figure; as in the Hebrew ענד English *bind*, *bond*, *bound*, *round*, Celtic *cruin*, Latin *rotundus*.

From the same root, *on*, *ain*, a circle, the Latins formed *annus*, a year, and *annulus*, a ring, that is, a little circle. The same word is the basis of *Janus*, the Roman deity, which was represented by a figure with two faces, emblematical of the past and coming year. His name

* "Saturnus ipse, qui auctor est temporum, et ideo a Græcis immutata litera Κρονος, quasi, χρονος vocatur, quid aliud nisi sol intelligendus est?"....*Saturnalia*, *lib*. i. *ca*. 22. I copy this passage from Faber, vol. ii. p. 31, not having the original to consult.

† Parkhurst's Lex.—Focaloir. Gaoidhilge-Sax.Bhearla.—Ludolf's Lex. Eth. 461. Amhar. 73.

‡ Gen. xli. 45.

§ See Gen. xiv. 18, 19, 20, and xl. 17.—Deut. xxviii. 1.—Gebelin's Alleg. Orient. Hist. de Sat. vol. i. p. 5.

was originally written *Eanus*, which was the Celtic *ean*, a circle, with the Greek article ος.*

From this deity, it has been conjectured, *janua*, a gate, and *January*, the first month, received their names. But *Janua* is from the common root of the Irish *gion*, the mouth, and the English *yawn;* while *January*, in Irish, Celtic *gionbhar*, is a compound of *gion*, mouth, opening, and *var*, a day, a revolution, a circle, still subsisting in Hindoostanee, and corresponding with *bar*, the root of many words in European languages. It forms the termination of *September*, *October*, *November* and *December*.†

Saturn, the Latin name which corresponds to the Greek κρονος, is probably a compound of *sat*, *sed*, שדי, *Sator*, father, Creator, Lord, the root of the modern Arabic *seid* or *seyd*, a title given to the descendants of Mahommed, and of *urn*, the root of *turn*. The latter root is seen in *diuturnus*, *aeternus*, *diurnus*, *hodiurnus;* it is in the Icelandic language, denoting *duration;* and is evidently the Coptic *ornos*, heaven. The radical sense of this word, therefore, is a *circle;* and we observe the Latin *fornix*, an arch, with a different prefix to *urn*, and *fornax*, *furnus*, a *furnace*, an oven, formed in the same root, from their circular figure. *Saturn* then signifies, the *father time*, or time the author of production. Possibly, however, the first syllable may be from the Celtic *seather*, strong, a title given to the deity by the Irish.

Saturn is called the oldest of the gods; and from the destructive effects of time, he is very significantly represented as armed with a sythe, the emblem of destruction and mortality. Hence the fable that Saturn devours his own *children*, seems to be derived from his name and

* Faber on the Cabiri, vol. i. 77. from Macrobius Saturn. lib. i. ca. 9. In Greek, his name was Ιαν, precisely the Celtic *ean*, the root of both the Latin and Greek names; χαίρ Ιανε προπατωρ ζευ αφθίτε. See Hymn to Proclus. Pausanias, iii. 272. translation. Let it be remarked once for all, that the termination of Greek names, ος, η, ον, which the Romans changed to *us*, *a*, *um*, are the Greek article added to names and attributes for the purpose of distinguishing gender and case, and must always be removed in order to discover the radical word.

† Vallancey, Orient. Collections, vol. ii. 115.

character, as *sator*, the sower, the parent of productions, which ultimately fall before his all-devouring sythe.*

That the syllable *urn*, in Saturn, signifies *round*, we have this further evidence, that in Irish Celtic, *Saturday* is called *Dia Sathruin*. Here *ruin*, is the Celtic *cruin*, *round.*

Uranus, the same as *Coelus*, says *Lempriere*, is from the same root as *Cronus*, *ean*, *ain*, a circle ; but probably with the oriental, *ur*, fire, the root of *uro*, to burn, and of πυρ, and *fire*, prefixed. *Ur*, is the root of *Orus*, or Horus, an Egyptian deity and son of Osiris and Isis, and the same as Apollo, the sun.† Hence *Uranus* signifies, according to its radical terms, the *fiery orb*, or *circular fire*, and signified originally the sun, as *Urania* did the moon; and also the heavens, the illuminated concave, the Coelus.‡

From these etymologies, which I believe to be indisputable, we infer the true origin of Cronus or Saturn.--- This deity is nothing more than *time* or *duration personified*. The primitive nations gave to time or duration the names of the circle, circles, or revolutions of orbs, by which time is divided into regular portions or periods.--- Hence Cronus is represented in fable as the son of *Coelus* and *Terra ;* the offspring of the heaven and the earth ; or the effect of the revolutions of the great orbs which compose the system. After the original of these names was lost or obscured, the fancy of men, unrestrained by correct historical or astronomical knowledge, gradually formed them into superior beings possessing life and intelligence.

* Hesiod. Theog. 137. Virg. Æn. viii. 319.—שדי is frequently used in the Hebrew Scriptures, and in union with *al* or *aleim*, is translated *God Almighty*. In Schmidt's Latin Version, these words are rendered, Deus Fulminator.

† Herod. Uterpe. 144. *Ur* is the Hebrew אור light, or חרה to burn, to heat.

‡ In the Cantabrian dialects, we observe that the name of heaven is the very root of *cronus*, viz. *cirena*, or *carena*, from the Celtic *crun*, round.—Chamberlayne's Oratio Dominica, p. 44. The Coptic name of heaven, *ornos*, seems to be from the root of *turn*, *furnus*. In Arabic, *curana*, in Chaldaic, *cren*, or *caran*, is a circle. It is the Celtic *crun*.

Coelus, or heaven, that is, without the termination or article, *Coel*, is the Celtic Irish *Ceal*, heaven, the Greek κοῖλος, concave, hollow, from a root whose signification is *bending*, *hollow*, Hebrew קלע to scoop out, English *hole*, *hollow*. This name of heaven, then, is given to the vault over our heads, from its apparent concavity. Hence in in Hindoo, *Cala* is time, probably from the apparent revolution of the heavenly orbs. And it deserves notice that the Teutonic *himel*, heaven, is formed from *Cam*, *ham*, crooked, bending, arched; and hence it signifies not only *heaven*, but a canopy.

Terra, the earth, is formed from the Celtic *tir*, earth.

In the creation, Hesiod makes chaos to precede the formation of the earth, but he makes the earth, the first constructed body, the parent of Coelus; or Ουρανος, made as a canopy for the earth and the seat of the gods. The earth in conjunction with heaven produced the Ocean, Thea, Rhea, Japet, and several other deities, with the Cyclops and giants.*

Titan is represented as being the son of Coelus and Terra, and the brother of Saturn. "The most ancient mythologists," says Lempriere, "make no mention of Titan. The name is applied to Saturn by Orpheus and Lucian; to the sun by Virgil and Ovid, and to Prometheus by Juvenal."†

* See Hesiod's Theog. v. 116—and Ovid's Metam. lib. i.

Ante mare et tullus, et, quod tegit omnia, Coelum,
Unus erat toto naturæ vultus in orbe,
Quem dixere chaos; rudis indigestaque moles.

† In nemus ire parant, ubi primos crastinus ortus,
Extulerit *Titan*, radiisque retexerit orbem.
Virg. Æn. iv. 118.

Nullus adhuc mundo praebebat lumina *Titan.*
Ovid. Metam. i. 10.

Et meliore luto finxit praecordia *Titan.*
Juven. Sat. xiv. 35.

That *Titan* and *Prometheus* were used as different names of the same object, is evident from the fact, that the ancients considered them as the immediate agents in creating man, or infusing into him his intellectual principle, the etherial fire. See *Prometheus* in the sequel.

Titan is certainly a denomination of the sun, and probably of Celtic origin. It is the Irish *Tethin*, sun, formed from *teith*, heat, with *on*, or from *di*, *ti*, light, the root of *deus*, *day*, *dies*, with the Celtic *tan*, *teine*, fire, written in other dialects *zan*, *tzan*, *sun*. The syllable *ti* or *di*, the root of *dies*, *dius*, διος, signifies in Chinese, high, elevated. The radical idea may be *high*, or *light*; for the early nations of the world used the same word to express very different ideas, when bearing some analogy to each other, as we still use *great*, *high*, *illustrious* and *splendid*. I find on tracing words to their primitive roots, that the same words are used to express *high*, *head*, *chief*, *great*, *illustrious*, *prince*, and other similar ideas.*

Jupiter, says Bochart, is Ham or Cham, the son of Noah. Faber observes that although under the name of *Jupiter* or *Hammon*, the Egyptians worshipped their ancestor *Ham*, yet this deity seems not unfrequently to be Noah himself. He then proceeds to retail the ancient fables respecting his birth and offices, as if he had been a real being.†

Jupiter is usually supposed to be compounded of *Jove* and *pater*, father Jove. Vallancey supposes the last syllables of the name to be the Irish *peiter*, a thunderbolt.‡

Jupiter is indeed a compound word of which *Jove*, *Jah*, the *Jehovah* of the Jews, is certainly the basis. The origin of this name exhibits, in a striking manner, the process of forming language. In most languages, as far as my information extends, the terms used to signify *spirit*, or the intellectual principle, are primarily the names of *breath*, *air*, *wind*; as *anima* and *animus*, ανεμος, *spiritus*, πνευμα.---- Now the Hebrew word יהוה *Iheue* or *Iove*, from the verb הוה *heue*, or *eue*, *to exist*, that is, to *breathe*, is a mere onomatope; an imitation of a strong expiration, or for-

* Gebelin. Monde Prim. vol. i. 51, and ii. 63. It is worthy of remark that the Teutonic nations form their word *day*, from *ti*, *di*, or *dis*, light; while the Slavonic nations use our word *sun* for the same purpose, calling *day*, *dzen*, or *dzien*....Cluver. Germ. Antiq. lib.i.26.

† Bochart, lib. i. ca. 8.—Faber, vol. ii. 292.

‡ Orient. Coll. ii. 102–7. Has this name any connection with the *Yapet* or *Japet* of the Hindoos? *Jyapeti* is Lord of the earth. Asiat. Res. iii. 312.

cible emission of breath, intended to express an idea of *breath* or *life*, and of course *spirit*. In its primary sense, then, *Jove* is *breath* or *air;* hence the character of Jupiter among the Pagan nations, who uniformly considered him as the deity that presided over the atmosphere.

As breath or air among most nations is made to represent the immaterial principle, soul, spirit, the Jews at first used, and Christians at present, use the word *Jehovah* to signify the universal, eternal and infinite spirit, or Supreme being. From the same aspiration, variously modified, have sprung many words signifying *being* or *life;* as to *be*, Welch; *buy*, to live; Greek Βιοω, Latin *vivo*, Greek εω.*

Apollo, it is universally agreed, is the sun. The name, in Celtic, *abellio*, is formed from *ab el*, the father sun, or more probably from *ball*, *bol*, a round body, from its figure. It is the *bel*, *belus*, of the orientals.

Phoebus, Φοῖβος, from Φαω, to shine, another name of the sun, scarcely requires an explanation.

The worship of this luminary, the sun, was not confined to the east; it was common among the Celtic and Teutonic nations, and under the same name *Bel*, or *Beal*. This fact is proved by a word which remains in the Irish language to this day. In ancient times, it was customry in Ireland for the druids, on May day, to make large fires on the summits of hills, and drive cattle through them, to secure them against contagious distempers; using, at the same time, certain ceremonies for the expiation of the sins of the people. On that day, all the inhabitants extinguished their fires, and lighted them from the sacred fires of the druids. This practice gave name to the month of May, which is still called the month of *Beal-tine*—the month of *Bel's fire*.†

There is another fact equally evincive of the prevalence of Sabianism in Germany. Tacitus, in his An-

* Hebricians inform us that the radical sense of הוה is to *settle* or *subside;* a singular explanation of *existence!!*

† Focaloir, p. 44.—Cesar informs us, in a passage to be hereafter cited, that the Gauls considered Apollo, the sun, as the power that preserved them against diseases.

nals, informs us, that Germanicus, when making war upon the *Marsi*, within the modern diocese of Munster, destroyed a temple called *Tanfane*, which was held in the highest veneration by the inhabitants. *Tanfane*, *tan* or *teine*, fire, the sun, and *fanum*, a temple, signifies the *Temple of the Sun*. This is a remarkable fact; for we read of no other temple of the kind, among the primitive Celts or Teutones of Europe; and the Druids of Britain had no covered temples. The fact however seems to warrant an opinion, that as those nations advanced in improvement, they began to imitate the practice which prevailed in the east and south, of erecting durable edifices for worship—a practice which was perhaps interrupted first by the Roman conquests, and afterwards by the introduction of Christianity.*

Of the origin of *Mars*, *Mavors*, the god of war, there are various opinions. The name is generally supposed to be formed from the Greek αρης, *iron*, as iron is the principal instrument of war; and the use of *Martial*, in the old chemistry, to express what belongs to iron, seems to favor this opinion. The word may equally well be deduced from the Greek ερίς, contention, rixa, according to the opinion of Cluver, who informs us that this deity was called by the ancient Celts, *Net*, a word, which, in the old Egyptian, as in some modern dialects of Germany, signifies *contention*.† In some parts of Germany, *dies Martis*, or Tuesday, is called *Erich-tag*, Erick's day; and *Erich* was a common name of princes and oth-

* Tacit. Ann. lib. i. 51.—Murphy's Note on the passage, vol. i. 473.—Cluver. Germ. Antiq. lib. i. ca. 26. The latter author gives a ludicrous explanation of the word *Tanfane*—*Th'anfang* the beginning. The word *fanum* seems to be formed from the Celtic *maen* or *vaen*, a stone—and the first places of worship seem to have been inclosures of stones.

† The word in Irish is *Neith*, battle, fight; and Cluver informs that this was the Egyptian orthography....*lib.* i. *ca.* 28. He cites passages from Plato in Timaeo, and from Macrobius, who expressly mention this Egyptian deity. The existence of this word *Neith*, in the Egyptian and Celtic languages, in Spain, Ireland and Germany, is a fact worthy of notice. It is probably the root of the Latin *nitor*. In Swedish, *nit* is zeal.

er distinguished characters, among the Teutonic nations. It is doubtless the word found in the composition of many Greek names of heroes, or princes, some of them said to exist in the fabulous ages, as Erechtheus, and Erichthonius, the latter of whom was supposed by the Greeks not to have been a mortal, but the son of Vulcan and the earth.* We have the simple word in *Eryx*, a fabulous hero, who wrestled with Hercules.† And indeed the word is no other than the Latin *rixa*, contention, struggle, exertion.

Of the origin of Mars, and the connection of his name with iron, the following appears to be a satisfactory explanation.

In the primitive languages, the word אור *ar*, *oir*, *ur*, signifies light or fire; Hebrew אור light, Hiberno-Celtic *ur*, fire, whence πυρ, and *fire; or*, gold, from its shining color, whence *aurum*; oir, golden, and the Celtic *oirthear*, eastern, from the light of the rising sun. Hence the Latin *orior*, *oriens*, from the same circumstance.

From אור the Hebrews formed מארת *mart*, a light, a luminary....Genesis i. 14, 16—and אורים, *urim*, brilliants, set in the breast plate of the high priest....Exodus 28. Hence the English *ore*, and the Greek αρης, polished iron, from their shining appearance.

Another root of equally extensive use, if indeed it was not originally from the same stock, is בר, *ber* or *bar*, to be clear, ברה *berhe*, bright, which with הל, to shine or glisten, forms the French *briller*, whence we have *brilliant*. With this root corresponds the Arabic verb בהר *behr*, to shine or be splendid, and the Hebrew בהיר *beir*, bright, resplendent.

From the same stock, sprung the Ethiopic *berhe*, bright, lucid, resplendent, which is precisely the Hebrew ברה. Hence the Ethiopic verb *barhe*, he shone; and the nouns *barhe*, refulgence, *beron*, light, brightness, *berar*, silver, and *brat*, or *bart*, *brass*.

In the Amharic, the present prevailing, but demonstrably the oldest dialect of Ethiopia, *ber* is silver, the Ethiopic *berar; bar*, a verb, he shone, luxit, splenduit; *berhe*, lucid, refulgent; *beron*, light, splendor; *mebart*,

* Paus. lib. i. ca. 2. † Paus. lib. iii. ca. 16.

a light, or that which shines; *beron*, parchment, the root of *membrana*, from its clearness, a word whose origin I have never seen explained; and it is the same in both dialects of Ethiopia. Now it is remarkable that in this dialect, *bart* or *bert*, signifies iron, and *berto*, is *fortis*, brave; the verb *bert*, is to acquire strength, and *bertet*, is force, strength, hardness, *fortitude*. Who does not see in these words the Latin *virt*-us, *fort*-is, *fortit*-udo; the Italian *forza*, *force*; and the French and English, *brave*, in *berhe*, or *barhe*, bright?

It will perhaps be suggested that *vires*, *virtus*, *fortis*, originated in *vir*, a man, and this, in the Hebrew גבר, geber, to be strong: But I am satisfied that these words conveying the idea of *strength* or *courage*, are all from the radical sense of בר, bright, to be shining, splendor.

Men, in their primitive state, had no words to express abstract ideas. They first gave names to *visible* objects, qualities and actions; and to express abstract ideas or moral qualities, used some word expressing an idea of a sensible object or quality, which, in their opinion, had some analogy or similitude to the abstract idea. Now what terms so naturally express *strength* and *bravery*, as those which signify that striking visible quality, *brightness*, *splendor?* We observe the same connection of ideas still in use among our common people, who characterize a person of unusual powers of mind or body, by the epithet *bright*—he is a *bright fellow*, or a *bright genius*.

It is a fact confirmatory of this opinion, that among all the Celtic nations, the Latin *vir*, or the equivalent term, was pronounced *baro*, or *bero*, precisely the Ethiopic and Amharic *barhe*, or *berhe*, bright.* In the authors of the middle ages, the word is written *baro*, *varo*, *varro*, *bero*, *bir*, *paro*, and *viro* or *viron*. See *Spelman's Glossary*,

* "Concurritur ad Cassium defendendum; semper enim *berones*, compluresque evocatos cum telis secum habere consueverat." Hirt. Pansæ de Bel. Alex. 42. These *barones*, barons, were the retainers or body guards of the German chiefs, young men of distinguished bravery, mentioned by Tacitus. "Principum, cui plurimi et acerrimi comites, hæc dignitas, hæ vires, magno semper electorum juvenum, globo circumdari, in pace decus, in bello præsidium"....De Mor. Germ. 14.

under *baro*. This is the modern *baron*, a man of bravery, a soldier, in its peculiar application, during the martial and feudal ages.

In conformity to the same ideas, our Saxon ancestors, used the word *bright*, as an affix to the names of princes, as in *Ethelbert;* the Saxon orthography *berht* corresponding exactly with the Ethiopic, *bert*, *berto*.

In the Celtic languages, *mar*, bright, corresponds with the oriental root בר, by the change of *b* into *m*—a change so frequent in the ancient languages, as to occasion neither surprize nor embarrassment. Hence the Latin *Mars*, *Martis*, corresponding with the Hebrew מארת, mart, a luminary, is brightness, or bravery personified, and constituted the god of war. And hence we see the reason why the names of iron, silver, gold and brass, in various languages, have a common origin with Mars.*

It may be remarked further, that the English word *brand*, a sword, received its appellation from the same idea of brightness; being merely the participle of the Saxon *brennen*, or rather the Swedish *branna*, to burn, to shine. We still retain the use of the word, but apply it to a different object.

The latin *Mavors* seems to be formed from the same radical word as *Mars;* perhaps by corrupting *mars*, or *vir*, into *vors*, and prefixing the oriental *ma*, great.

The English word *war*, which is of Celtic origin, in French *guerre*, seems allied to the root of *Mars*, and *ferrum*, as Gebelin has observed; but the fact may not be unquestionable; for *guerre* bears a strong resemblance to the ancient *gerrha*, an oblong shield, used by the Persians; and if this word is the root of *guerre*, the radical sense of war is to *shield*, to protect, or defend. And it is to be observed that *war* and *guard*, *guerre* and *garantir*, may be easily deduced from one radical sense.†

* See Parkhurst, under the radical words mentioned, and Ludolf's Lex. Eth. Column. 231. and Amharic. Col. 40, 41.

† Φορουντες γαρ μίκρα δοράτία καί επίμηκεςτερα οπλα κατα τους Κελτικους θυρεους, η τα γερρα τα Περσων.

Bearing small spears and more oblong shields, like the Celtic Thureoi, or the *gerra* of the Persians....*Pausanias*, *Arcadics*. ch. 50. The same author, in his Phocics, describes this shield as made of small twigs, or wicker work.

Faber supposes *Mars* to be the solar orb, from the Hebrew חרס, cheres, used in Job ix. 7; otherwise the Babylonian *Belus;* and under this name, he supposes Noah was anciently worshipped.*

I would only remark further, that the *Berith* and *Baal-Berith* of the Scriptures, is unquestionably this same deity, *Mars*. Parkhurst is correct in deducing ברית from בר: but mistakes the meaning of the word. *Berith*, is the Ethiopic *barto*, *bright*, *brave*, *fortis*, the god of war.---- See Judges viii. 33, and ix. 46.

Hercules, says Faber, was *Arech-El*, the solar god of the Ark, or Noah. Bryant supposes the Herculeans to have been Cushites of great enterprize, who rambled over the earth, building cities, establishing the worship of the sun, and performing great achievments. Capt. Wilford, of the Asiatic Society, supposes Hercules to be the same character as the *Heracula* of India, representing the race of *Heri* or Jupiter.†

Gebelin considers Hercules as the representative or protector of agricultural improvements, the culture of the earth, or in general, the labors of men united in civil society. He supposes Saturn, Cronus, or Osiris to represent the *invention* of agriculture, and Hercules, the cultivation of the earth—and hence he is called the General of Osiris.‡

To discover the real origin of this fabulous deity, we are to find the meaning of his name. This is easily found in his principal characteristic, *labor;* for amidst all the confusion which ignorance and fiction have engendered on this subject, the *labors* of Hercules are proverbially attached to his history. This characteristic leads us directly to the origin of his name, which is formed of the root of *work*, *erk*, in German and Dutch *werk*, whence the Greeks formed εργον and εργαζομαι, with κλεος, fame, praise.

* Faber on the Cabiri, vol. i. 175.

† Bryant's Analysis, vol. ii.—Faber, i. 125, 240,—Asiat. Res. vol. iii. 408, and v. 270. The Indian *heri*, is probably the Irish *Earr*, Latin *herus*, Lord; and the Indian *Bel*, or *Bola*, is undoubtedly the Hebrew and Ethiopic *Bol* or *Baal*, Lord. These words correspond in sense with *Hercules*, but had no primitive connection.

‡ Alleg. Orient. Hist. d'Hercule. Monde Prim. vol. i. p. 173.

Hercules, then, is a common name of any *famous worker;* any person of distinguished *labors*, or achievments; and ancient authors alledge that there were many persons of this name.*

Hercules, then, was a name originally given to any bold, enterprizing hero or adventurer; any distinguished warrior, hunter, or robber, who, at the head of a tribe or band, performed extraordinary feats of valor. The application of this name to the sun, or to the zodiac, the twelve labors of Hercules representing the twelve signs or months, if it is not altogether a fiction, must have been long posterior to the origin of the name, and its application to individuals of enterprize.† This inference is naturally drawn from the statues and figures of Hercules, which represent him as covered with the skin of a lion, and armed with a knotted club. These circumstances prove his origin to have been in the most rude and savage state of man, when his clothing consisted of skins, and his arms of a rude, unshapen club, the first instrument of death among men, before the knowledge or use of metals; and indeed as Hercules bears not a bow and arrows, we may conclude that his character was formed before the invention of those weapons. *Hercules*, then, originated in the very earliest ages of man, and represents a savage warrior or hunter, clothed with a skin, and armed with a club. His character being formed and attached to this name, the name was, in subsequent periods of society, applied to any bold, enterprizing chief of a warring or migrating horde, whose *labors* or achievments became the subject of songs, and were handed down by tradition, perverted by fancy or ignorance, and embellished by fiction. These fables were afterwards committed to writing, and now form the basis of the pagan mythology, and even of the Greek and Roman poems and history.

* Quamquam, quem potissimùm Herculem colamus, scire sane velim; plures enim tradunt nobis ii, qui interiores scrutantur et reconditas literas....*Cicero De Nat. Deor. lib.* iii. 16. This author enumerates six of this name, and mentions that one of them, a native of India, was called *Belus*.

Ηρακλεῖ δε ως πολλους τε καί χαλεπους τελεσϵίεν αθλους. Hercules performs many and difficult labors....*Paus. lib.* viii. 32.

† See Gebelin's History of Hercules.

In the obscurity which these fables have thrown on the history of the pagan deities, we have little certain light, except what is derived from the radical sense of their names, and from the drapery and appendages of their statues. The former have retained their primitive signification, and the latter their form—and the club of Hercules, like the Latin *pugno*, to fight, from *pugnus*, the fist, bears along the stream of time an imperishable memorial of the manner of fighting in the age when the character and name of Hercules originated.*

Bacchus, says Bryant, was Cush, the grand-son of Noah. Bochart forms his name from *bar-chus*, the son of Cush, and supposes him to have been the celebrated *Nimrod*. Faber maintains that Bacchus was Noah himself, and the revels of this deity have been fancied to bear some allusion to the intoxication of the diluvian patriarch. Wilford has strangely supposed that *Bacchus* is a title corrupted from the Indian *Bhagavat*, or preserving power. Gebelin, on the contrary, alledges and attempts to prove, that Bacchus was the same as the sun; that at first he was an allegorical being, representing the influences of the sun in producing and ripening corn and the vine; and afterwards he was considered as an illustrious personage, the author of these productions.†

But in truth Bacchus is an imaginary being, whose name was formed from the Celtic *bach*, drunk, by the addition of the Greek article. In Irish, *bach* is drunk, *bacchaire* a drunkard, and *bachla* is the root of the Latin *poculum*, a cup. *Bacchus*, then, is neither more nor less than hard drinking or intoxication personified, and in progress of time, exalted into a deity. He was also called Dionysus, or Dionysius, and Cicero informs us that "Dionysos multos habemus," we have many Bacchuses. The number, it is believed, has not been diminished by time.‡

Bacchus is represented by the figure of an effeminate

* See Herod. Euterpe, 44, 45.

† Bryant's Analysis, i. 257. 4°.—Bochart. Geog. Sac. lib. i. ca. 1. —Faber, vol. i. 155.—Gebelin, vol. iv. 541.—Asiat. Res. iii. 352, 395.

‡ Cicero De Nat. Deor. lib. iii. 23. *Bach* radically signifies a hollow, a cup, or bowl; so that *Bacchus* is literally the personification of a cup or bowl.

boy, some times holding a thyrsus, and a cluster of grapes with a horn, and crowned with vine and ivy leaves. He also sits upon a globe, bespangled with stars ; and often appears naked, riding upon the shoulders of Pan. The last circumstance may perhaps be an emblem of the effects of wine in giving courage, and of the bacchanalian's contempt of fear.

Mercury, according to Bryant, was the sun. Faber believes him to have been the solar Noah. Bochart supposes him to have been Canaan, because he presided over commerce ; while Cluver labors to prove that *Thoth* or *Taut*, the Egyptian Mercury, was really the true God, who was worshipped in ancient Germany, under the title of *Tuisto*. From this deity, he supposes the Germans received their common appellation of *Teutons*. Faber forms the name from *M'erech-ur*, *the great burning divinity of the ark ! !*

Gebelin alledges this name to be Celtic, and compounded of *merc-ure....*(*mark* and *vir*) a man of marks, letters, or signs, as he was the deity of speech, and interpreter of the gods. The usual derivation of his name is from the Latin *merx*, trade. But Gebelin supposes the Hebrew מכר, (whence merx) signifying exchange, sale, or wares sold, to be formed from the primitive *merc*, a mark, from the practice of marking goods for barter or sale.*

The *Mercury* of the Romans was evidently the same character as the Egyptian *Thoth*, *Thot* or *Taut* and the Grecian Ερμης, Hermes ; although authors mention several personages under the same name. Gebelin alledges the Egyptian name *Thot*, *Taut*, to signify a sign or mark ; and hence his character as the deity of letters. In the Celtic dialects, we find a word equally expressive of his character, from which this name may have originated ; in Welch, *tavod*, in Armoric, *teaut*, the tongue. The first etymology makes this personage the god of *letters ;* the last, the god of *speech*. *Thoth*, then, is *letters* or *speech* personified and deified. Hence his principal offices were to instruct men in the knowledge of letters and useful

* Bochart. Geog. Sac. lib. i. ca. 2, and De Phoen. lib. i. 42—Bryant, i. 338—Faber, i. 283—Cluver. Germ. Antiq. lib. i. ca. 9. 22, 23, 26—Gebelin, vol. i. Alleg. Orient. p. 43 and vol. iv. 57.

arts, and to act as the interpreter of the gods. His Greek name *Hermes*, from Ρημα, a *word*, *speech*, gives the same result.*

Hence we observe Mercury is the god of speech, of letters, and of commerce; or an imaginary being representing speech, trade, and mutual intercourse, by the use of language and letters.†

As in the Celtic language, *marc* or *merc* was a horse, it is not impossible that some of the ancients might mistake the origin of the name of Mercury, supposing the first syllable to signify a *horse*, and hence assign to this personage the character of a horseman, a messenger; and represent him as presiding over travellers. Cesar, in a passage hereafter cited, gives countenance to the opinion that this was the real origin of his name.

Dragon, draco, Bryant supposes to be an imaginary being, formed by mistaking *Tarchon*, a watch-tower, with lights, and writing it *trachon*. Faber says that the dragon of ancient mythology was merely a large serpent, and not an imaginary being.

Gebelin cites, from a fragment of Sanchoniathon, that Mercury taught that dragons "abondoient plus en esprits que tous les autres reptiles; qu'ils étoient d'une nature ignée; qu'ils se mouvoient avec la plus grand vitesse, quoique privés des organes communs à tous les autres animaux."----Dragons abound with spirits, more than other reptiles—they are of a *fiery* nature; they move with the greatest celerity, although not furnished with the organs common to all other animals.

* See Gebelin ut supra—Lhuyd. Arch. Brit. p. 80. Cicero, speaking of Mercury, and enumerating several of the name, says---"Quintus, quem colunt Pheneatae, qui et Argum dicitur interemisse, ob eamque causam, Ægyptum profugisse, atque Ægyptiis literas et leges tradidisse. Hunc Ægyptii *Thoth* appellant"....De Nat. Deor. iii. 22.

† The people of Lystra called Barnabas, Jupiter, and Paul, Mercury, because he was the chief *speaker*....Acts xiv. 12. See Bochart. Phoen. lib. i. 42, and the authors cited. Philo Byblius, from Sanchoniathon, says *Taaut* originated *απο Μισωρ*, from Misor or Egypt; and Plato in Philaebo, says *Thoth* invented a multitude of words.... See also a passage from the Abbe Caperan in the Oriental Collections, vol. ii. 404.

The real origin of the name is the Celtic *drag*, fire, and from the descriptions of these beings, it is evident that *dragons* were fiery meteors, or shooting stars, which, darting and flaming along the sky, were imagined to be *fiery serpents*, which frightened the rude nations of antiquity. The name was afterwards applied perhaps to real serpents.*

Parkhurst arranges the Hebrew word תנים dragons, under the root תנה, to shriek or wail. What sort of dragons or serpents are those which *shriek* or *wail?* And what resemblance is there between *wailing* and *hissing?* The Hebrew word is undoubtedly a plural of the Celtic *tan*, fire; the root of the Chaldaic word *tanin*, smoke, and this etymology coincides with that of *dragon*. There are many Hebrew words remaining, whose roots are not found in the Hebrew language, but which are still a part of the northern and western languages of Europe.†

Lares, household gods, is merely the Celtic name *lar*, a floor, originally the ground or level earth, as this constituted the floor of all rude nations: Irish *lar*, Welch *lhaur*, whence we have *floor;* Cantabrian *lurra*, ground, the earth—This word answers nearly to the *Teraphim* of the Scriptures, the root of which is the Celtic *teref*, a house. *Penates*, in like manner, is formed on *penus*, an inner room, a word mentioned by Festus.‡

Pan, Lord Bacon supposed to be the Greek word παν, omne, intended as a personification of the universe; and with him agrees Cluver. Faber suggests, that *Pan* is an abbreviation of *Phanes*, from *ph-ain-es*, the solar fountain of fire, or Noah worshipped in the form of the sun. Bryant maintains that Pan, like the other Roman deities, represented the sun. Gebelin, from Macrobius,

* Gebelin, vol. i. 103—Faber, i. 208—Focaloir—Lhuyd. under *ignis*—Vallancey's Essay on the Celtic Language, Gram. p. 5.

Shakspeare evidently alludes to fiery meteors, when he says,

"Swift, swift, ye dragons of the night."

The Celtic *drag*, fire, is probably a compound of the root of *ignis*, in Hindoo, *ag*, in Gipsey, *iag;* and the root of *traho*, *draw*, *draag*, a fiery train—a precise description of a fiery meteor.

† Orient. Coll. i. 306.—Park. Lex.

‡ Ainsworth's Vocab. of obsolete words.

alledges that *Pan* and *Faun*, are the same divinity, and both represent the sun, the soul of the world, and of all nature. Bochart supposes *Pan* and *Faun* to be the same; but he assigns a different, and in my opinion, the true etymology of the word.

The ancients considered Pan as the god of shepherds, a monster in appearance, with horns on his head, having a flat nose, and his lower limbs like those of a goat. His residence was in forests and on rugged mountains. In these descriptions, we discover the origin of this pretended deity, whose characteristic was to excite *sudden terror*. We retain the evidence of his origin in the word *panic*, not from Pan, a captain of Bacchus, who, with a few men, routed an army, by means of echoes in a valley, as Polyænus alledges; nor from the terror, with which Pan struck the hearts of the giants, in the wars of the Titans; but from the Celtic word *ovan*, or *obhan*, which signifies *fear*, *terror*.

Bochart observes that Pan is found in Psalm lxxxviii. 15. נשאתי אמיך אפונה. "While I suffer thy terrors, I am distracted," or, I suffer thy terrors, so as to be astonished or confounded. "Portavi terrores tuos, ita ut obstupescam," as Schmidt has rendered the words.—The word here rendered *distracted*, is evidently from the same root as the Celtic *ovan*, *v* and *p* being convertible, and frequently changed, the one into the other.—*Pan* therefore is merely fear, or terror; and in process of time, the meaning of the name being lost among the Greeks and Romans, this name was mistaken for that of a real being, and deified.—If we consider the defenceless state of savage men, condemned to roam in the forest in quest of food, perpetually exposed to the attacks of wild beasts, we shall be at no loss to account for the origin of the god of terror, nor for his residence in woods and on rugged mountains, nor for the frightful figures under which he was represented.*

* Asiat. Res. i. 267.—Cluver, lib. i. 26.—Faber, i. 160.—Gebelin, iv. 418.—Bochart. Geog. Sac. Canaan, lib. i. ca. 18. Pausanias, lib. x. ca. 23, informs us that terror, produced without apparent cause, is sent by Pan. Let it be remarked, that the Celtic *bh*, in Irish, are pronounced as *v*. *Obhan* in Irish, is precisely the Welch *ovan;* and *V*, *P* and *F*, are perpetually interchanged in the ancient languages.

Neptune, says Bochart, was Japhet; for Japhet possessed the isles of the Gentiles, and the maritime countries. Faber thinks the word composed of *Nu-hiph-tanin*, which, according to him, signify the *Hippian-Fish-God*, or Noah, in allusion to the ark and deluge. Vallancey supposes this word to be compounded of the Celtic *naomh*, a saint or deity, and *tonn*, *tun*, a cistern, which would make Neptune very justly the god of the deep.

But *Neptune* derives his name from a primitive word, signifying water, whose derivatives are numerous in Europe, Asia and Africa; and even in America. It is seen in the Greek Νίπτω, to wash or lave; in the Arabic *nap*, to drink or satiate with drink; in the Hebrew נבע, to gush forth, as a spring; in the Arabic *nebet*, to gush or spring forth, as water; in the names of a multitude of rivers, as in *Nieper*, *Enipeus*, *Neva*, in Europe; in *Nuba*, a lake in Africa; in *Nieva* and *Niepa*, in Siberia; and in *nebbi*, *nepee*, or *nepei*, the common name of water in the dialects of the American Algonkins, Knisteneaux, and Chipeways. The ancient name of the Ladoga, a lake in Russia, was *Nebo;* and a river in Spain was formerly called *Nabius*, or *Navio*.

Neptune, the god of the ocean, is then a mere imaginary being, whose name is taken from the element over which he presided; that is, Neptune is the ocean personified. Gebelin supposes the last syllable of this name, to be the Celtic *tun* or *dun*, profound. *Neptun*, the profound water. This is probable; but of the first syllable, the basis of the word, there can be no doubt.*

The *Nereids* are creatures of fancy, whose name is composed of נהר nehr, a river, a name still retained in Oriental countries, and εἶδος, form, species. They were the daughters of *Nereus*, the ocean, or son of the ocean, whose name had the same origin. The same word still exists in the Indian *nara*, water, and *nere*, a wave.†

* For authorities under this head, see Bochart, lib. i. 1—Faber, i. 125—Gebelin, vol. i. Hist. de Sat. p. 71—Parkhurst, under the words mentioned—Strabo, lib. viii. 3. 32—Plin. lib. iv. 8, and vi. 7—Pausanias, lib. ix.—D'Anville, p. 610—Ludolf's Lex. col. 304—Carver's Travels, p. 403. Dublin, 1779—Mackenzie's Voyage, p. 105—Mela. iii. 1—Tooke's View of the Russian Empire, vol. i. 224, 226—Vallancey's Essay on the Celtic Language, p. 22.

† Hesiod's Theog. 233, 240—Asiat. Res. vol. vi. p. 530.

The *Sirens*, sea nymphs, whose melodious and fascinating strains arrested seamen, and made them forget their employment, were also beings of fiction, deriving their name from שר, or שיר, to sing.

The *dryads*, or nymphs of the woods, receive their name from a primitive appellation of a tree, and εἶδος, form, species. The root of this word is common to the Celtic, Teutonic, and Slavonian families of men—in Welch, *deru;* in Irish, *darach;* in Greek, δρυς; in Slavonic, *drevu;* in Saxon, *treow* or *treo*, whence we have *tree*. The Greeks appropriated the word to the *oak*, but primarily and generally, the word is an appellative of tree.*

Nymphs, another name of imaginary deities, which presided over rivers and fountains, is formed from a primitive word signifying water; the root of *Nemea*, a river near Corinth, and of *Niemen* in Poland. The radical word, *nam*, or *naum*, water, still exists in several dialects of the Burman empire.†

There were also nymphs of the mountains, called *orcades*, from ορος, a mountain. These were the companions of Diana, in hunting. Others, called *Napae*, from Ναπος, ναπη, a grove or declivity, presided over hills and dales.

The *Naiads*, from ναίω, to flow, or the root of this word, presided over springs and rivers.

The sea nymphs were called *Oceanides*, from *oceanus* and εἶδος, species, form.‡

Orpheus, the celebrated musician, who is said to have softened, by the melody of his notes, the ferocity of wild beasts, and arrested the current of rivers, is represented to have been the son of Apollo, and to have received a lyre from his father, or from Mercury. But the name of this imaginary being is formed of two Celtic words, *oir*, gold, and *fead*, a whistle—the golden whistle. In the same language, *Oirfid* is music, and *Oirfideach*, the gene-

* See Lempriere, and the Lexicons of the several languages, and Hesychius under δρυς. The name, in some languages, seems to have been applied to the *oak*, by way of distinction.

† Asiat. Res. vol. v. 228.

‡ Hesiod's Theog.----Ovid. Met. xiv. 328----Virg. Georg iv.341----Æn. i. 500----Homer's Odyssey, lib. v. 348, et seq.

ral name of a musician. *Orpheus* is merely a personification of music.*

Osiris, a celebrated king and deity of Egypt, is a person that makes a great figure in history, as well as in fable. Faber alledges that *in reality*, Osiris was the same as Cronus or Noah; and to prove the point, he adduces an etymology from the Hiberno-Celtic, on the authority of Vallancey, who informs us, that in that language, *Eiss-Aire*, signify the commander of a ship.†

Osiris is represented as having civilized his own subjects, giving them salutary laws and teaching them agriculture. Afterwards he resolved to visit other parts of the earth, to spread civilization, and actually accomplished his purpose. On his return, he found his brother Typhon had raised seditions in his kingdom. In this story we have perhaps a representation of the revolution of the sun, in his diurnal course, visiting all parts of the earth; and perhaps its visit to Ethiopia may allude to the winter season. The disorders raised by *Typhon*, or the god of *darkness*, may represent the evils of night or of winter.‡

Osiris was undoubtedly a primitive title of the sun, the object of worship among most ancient nations. The word, Parkhurst supposes, to be formed from the Hebrew עשר, to enrich. But, in this, as in a multitude of other cases, Hebricians have inverted the order of derivation; for in Hebrew, as well as in Arabic and Ethiopic, this verb is formed from the same word, signifying *ten*, and the verb signifies to *give tenths*, and thus *to enrich*. In the sense of *ten*, this word is probably formed on the root שר, to measure, or regulate, from the peculiar properties of that number.

The real origin of the name is in שר, to regulate, rule, direct, as the sun is the regulator of time. Or, more probably, in זהר, brightness, splendor, to shine; whence our English *sear*. This word is also the root of *Sirius*,

* See the Lexicons of the Irish Celtic, Lhuyd's Archaeologia, and Focaloir, before cited.

† Faber, vol. i. 151, and vol. ii. 77.

‡ See Herod. Euterpe. 144----and the authorities cited by Lempriere, under *Osiris*.

the dog-star, as well as of the Indian *Surya*, which primarily denoted the sun; and of the Welch *Seren*, a star.

The wife of Osiris was Isis, and Sir William Jones supposes these characters to represent the powers of nature, considered as male and female. Now *Isis* is a Coptic word signifying the earth, still recognized in the word *isi*. As the sun, acting upon the earth, is the immediate parent of vegetable productions, it is not improbable that this circumstance gave rise to the fabled connection of Osiris and Isis.*

Pallas, was a name given to a giant, a son of Tartarus and Terra, who was killed by Minerva. The goddess covered herself with his *skin*, whence, as some suppose, she received her name, *Pallas*, pellis. This *Pallas*, the same as Minerva, was the daughter of Jupiter, and goddess of wisdom. There was also a *Pallas*, a son of Crius, who married the nymph Styx, by whom he had *victory* and *valor*. From these characteristics, as well as from the similitude of names, there can be little doubt that Pallas is a word formed from *pellis*, *pal*, *pell*, a skin, as shields were originally made of hides. Hence *Palladium*, a defense—the name given to the famous statue of Minerva, which protected Troy. The Gallans in Africa still make their shields of skins.†

Ogyges, is represented as the first monarch of Greece, in whose days Attica was laid waste by a deluge. He was the son of Terra or of Neptune. The root of this word is a primitive name of water—in Hiberno-Celtic, *oige* or *oice;* in Chaldaic, *oug;* in Ethiopic, *houg;* in the Livish, or Livonic, a dialect of Russia, *yogg;* in Latin, *aqua;* in Spanish, *agua;* in Portuguese, *agoa;* in Hebrew, אגם, the root of ocean. Hence the names of many rivers, as *oka*, *okka*, and others in the Russian dominions. To this word the Greeks added *gyges*, the name of one

* See Park. under the words mentioned, and Ludolf's Lexicon, Coll. 442—Asiat. Res. i. 253. Cluver, lib. i. ca. 27, cites the opinion of Macrobius. Saturn. i. 21. "Nec in occulto est, neque aliud esse Osirim, quam solem, nec Isin aliud esse quam terram." It is obvious that Osiris is nothing else than the sun, and Isis the earth.... See *Chamberlayne's Oratio Dominica*, p. 30.

† See Lempriere under *Pallas*, *Palladium*, and *Minerva;* and Ludolf's History of Ethiopia, b. i ch. 16.

of the Titans, mentioned by Hesiod; but it is probably from the Arabic *gog*, to *expand*, and signifies *great*.—There was a lake in Lydia named *gygaeus*, and there was a deity in Caria, called *Ogoa*, under whose temple the sea was said to pass. Hence it is obvious, that *Ogyges* is a fabulous character, representing the deluge; or his history may have originated in traditions respecting the deluge, and the diluvian patriarch. In Ethiopic, *aig* or *aich*, is a deluge.*

Morpheus, the god of sleep, had his origin in a word still found in the Ethiopic *orf*, to rest, *morf*, a place of quiet—probably from the same root as the Hebrew ערב, and מערב, the evening, or time of rest.†

Cadmus, who is said to have introduced letters into Greece, is supposed to have received his name from the Hebrew word קדם, the east, as letters came from the east into Greece. This is doubtless a mere conjecture, and the history of Cadmus, a fable, formed from the signification of the word. The word is oriental, and still retained in the Persian, *Kadeem*, which signifies language. The root is seen in the Teutonic verb which we retain in *quoth*, that is, *quod* or *quot*, from the Saxon *cwethan;* in *quote*, from the French, and in the Latin *cito*. And from the same root the Irish branch of the Celtic has *ceadach*, talkative, and *ceadal*, a story or narration. The Welch, from the same root have *gueyd*, and the Irish *guth*, a voice or word.‡

There may have been a person, who, for his knowledge in languages, was denominated *Cadem*, whence the Greeks and Romans formed Cadmus; but it is not very probable.

Argus, derives his name from the root of *arch*, which signifies to *curve*, *bend*, or *wind*. Hence we have *arch*,

* Lempriere under *Gyges*, *Ogyges*, *Gygaeus*, and *Ogoa*—Orient. Coll. ii. 13—Lhuyd's Archaeologia, under *aqua*.—Paus. lib. ix. 5—Tooke's Russia, vol. i. 234, 270, 405.

† Ludolf's Lex. col. 446, 447—Parkhurst, under the word ערב.

‡ Orient. Coll. i. 385—Focaloir, under *Ceadach*. From this root, *Cead*, speech, the Celtic Irish formed their name of Wednesday, or Woden's day, *dies Mercurii*, which they call *Dia Ceaduin*, or *Dia Ceadaoine*, the day of the speaker, or of the god of speech....Focaloir under *Dia*.

both in the sense of a part of a circle, and in that of *cunning*, *subtle*, *sly*. This root is retained in the German, Dutch and Swedish *arg*, signifying cunning, arch, crafty, wicked, mischievous. It is a curious fact, that many words in our modern languages conveying the idea of *craft*, had their origin in the radical sense of *bending*, *curving*, *winding*—a sense well expressed by *insinuation*. Of this I shall give ample proofs in my Dictionary, should I live to execute the work. From *arg*, by transposition of letters, we have the English word *rogue;* and on this root the Celtic nations formed the Welch *drug*, the Irish *droch*, evil. The ancients, whose fancy embellished every object, gave to Argus a *hundred eyes*—a happy emblem of cunning. Hence we see that *Argus* is a mere personification of craft, or vigilance.—Cicero informs us that Argus was slain by Thoth; that is, craft was overcome by intelligence, or learning.*

Prometheus, a son of Japetus by Clymene, surpassed all men in fraud and cunning, and deceived Jupiter himself. According to Apollodarus, he *made the first man and woman* on earth, with clay, which he animated by means of fire, which he stole from heaven; and he *erected the first altar to the gods*. Bryant thinks him the same as Osiris or Dionusus, Noah, the great husbandman, the planter of the vine and inventor of the plow. Faber alledges Prometheus to be *Atlas*, or the helio-arkite Noah, from *Phra-ma-theus*, the great solar deity!!

But *Prometheus* is a compound of two primitive words, *brum*, or *broum*, who was fabled to be one of the Centaurs, and *aith*, *ait*, Chaldaic את. Hebrew אש, fire, whence the Greek αἴθω, and the English *ashes* and *heat*. *Brum*, is the root of the Latin *primus*, and the Gothic *frum*, *fruma*, Saxon *frum*, first, beginning, origin; the Indian *Brumma*, and *Bramin*. The literal sense of the word is the *first fire*. Hence Juvenal uses the word Titan, the sun, as synonymous with *Prometheus*. Hence he is said to have animated the first man and woman, as heat is the principle of life; and hence, with great propriety, he

* Cicero. De Nat. Deor. lib. iii. 22....Ovid's Met. lib. 1 v. 720.

was supposed to have erected the first altar to the gods.*

Vulcan, is said by Faber to have been Noah, adored in conjunction with the sun. Bochart, and other authors, have supposed him to be the Tubal-Cain, mentioned in Gen. iv. 22. Bryant supposes him to be the sun, and his name to be formed from *Baal-cahen*, Baal the sacred. But *Vulcan* is a word formed on the Celtic *molc*, fire, the Moloch of the Scriptures, which may indeed have had its origin in *Bal*, *bel*, the sun. The last syllable may be the Hebrew אן, אין, labor, and if so, we have the exact interpretation of his name—a *worker in fire*. Bryant suggests, that the fable of Vulcan's ejection from heaven by Juno, relates to the overthrow of Babel, and the destruction of fire-worship. Cicero's orthography of this word, *Volcanus*, corresponds best with its etymology.†

Themis, a daughter of Coelus and Terra, was consulted as an oracle, in Attica, in the age of Deucalion. She was the mother of *Dice*, (δίκη, justice) of Irene, (εἰρηνη, peace) of Eunomia, (ευνομος, good laws) and of the Parcæ, or destinies. She is represented as holding a sword in one hand, and a pair of scales in the other, the emblems of justice still retained in use. This goddess derives her name from the Hebrew תמה, integrity, justice, of which she is a personification.‡

Anubis was an Egyptian deity, represented under the body of a man, with the head of a dog. He is supposed by some to be Mercury. This name in Ethiopic signifies a lion, and not improbably the resemblance between the animals may have led the ancient Greeks and Romans to mistake the Egyptian figure for a dog. His name is perhaps given to him for his growling sound; or if not, it bears such a resemblance to the oriental נב, *neb*, to ut-

* Bryant, vol. ii. 273, 4°.—Faber, i. 114.—Hesiod. Theog.—Paus. lib. ii. 14, and i. 30.—Virg. Ecl. v. 42. Ovid represents the son of Japetus as the creator of man....*Metam.* v. 82.—Bromus, according to Ovid, was killed by Caenus.....*Met.* xii. 459.

† Faber, i. 157.—Bryant, vol. iii. 47.—Bochart. Geog. Sac. De Phoen. lib. i. 12.—Phaleg. lib. iii. 12.—Cicero. de Nat. Deor. lib. iii. 27.

‡ Ovid's Met. i. 321.

ter, that the ancients were led to suppose he was intended as a figure of Mercury.*

Dædalus, is a mere personification of daring confidence, from the Irish Celtic *deadla*, bold; *deadlas*, boldness.

In an attempt to develope the origin of the fabled deities of antiquity, it would be unjust to omit the goddesses, who make a conspicuous figure in mythology.

Minerva, is probably derived from the same radical word as *Minos*, *Mentor*, μαντὶς, μην, *mens*, as a predominant characteristic of the goddess is *wisdom*. The latter part of this compound is found in the Irish *earba*, labor; German, *arbeit*, Dutch, *arbeid*, Swedish, *arbete*, labor, work, employment. Hence *Minerva* is the *skilful laborer*, the goddess of manufactures.

Vesta, the goddess of fire, is derived from the oriental radical, *ast*, *asta*, *esta*, Hebrew אש, fire, from which the Greeks had their αἴθω, to burn, and εστία, a hearth; the Latins their *asso*, to roast; and the English their *ashes*. From the supposed purifying effects of fire, this goddess became the patroness of the sacred fire, and of vestal virgins. The Hindoo deity *Agni*, whose name is from the same source as the Latin *ignis*, fire, has also the character of the *purifier*.†

Juno, the Hindoo *Yoni*, derived her name from the same root as the Greek their γυνη, woman, and she represents the generative powers of the species.‡

Diana, the goddess of hunting, is named from the Celtic word *dian*, which, in Irish, signifies swift, vehement. She is merely the representative of ardent boldness and celerity in the chase; qualities in high estimation among savage nations, who subsist chiefly upon the flesh of wild beasts. Hence the goddess is painted with a bow in her hand. Pausanias informs us that the Athenians had altars erected to shame, fame, and *impetuosity*.§

* Ovid's Met. ix. 689.—Virg. Æn. viii. 698. The word *neb*, we retain in *nib*, *nip*. From this root the Ethiopic has *nebeb*, or *nebab*, speech, and *nebia*, a prophet. The word radically signifies the *mouth*, and is found in the Celtic as well as the oriental languages.

† Park. p. 43, 44.—Asiat. Res. i. 263.

‡ Asiat. Res. iii. 364.

§ Pausan. lib. i. 17.

Venus, the goddess of love and beauty, is merely woman deified. Her name is a dialectical variation of the Celtic *bean*, woman; a word used in various languages; in Hebrew בני, beni; in Persian, *banou*, as *Ked banou*, mistress of the house; in Welsh, *benyn*, or *mennyu;* in Hindoostance, *bhavana;* in Irish, *ben*, or *bean;* in Cornish, *banen;* in the old language of Beotia, according to Hesychius, *bana;* in Burma, *pooen*, or *paeyen;* in ancient Thrace, *bendis*, which seems to be a compound of *Bean* and *dis*, or *dia*, goddess. The Irish word for a goddess is *baindia*, *bean dea*, a woman deity.*

As Venus was the representative of the female part of our species, we need not be surprized at the number of her temples, and the extensiveness of her worship. And perhaps the moderns, who deride the absurdities of ancient mythology, may make some apology for the worship of this goddess; for if, in the present age, we do not see the ladies actually deified, and temples erected to their honor, we not unfrequently hear them addressed as angels; and if the lover's professions are to be credited, they are sometimes *adored.*

Of the Teutonic deities, *Dis*, or *Tis*, *Thor*, and *Woden*, make the most conspicuous figure. *Dis*, *Dia*, *Zeus*, *Theos*, *Deus*, is the sun or Jupiter. It is certain that the Latin *dies;* the English *day;* the Irish *dia*, God, and *dia*, *die*, day; Welsh *dydh;* Hindoostanee *dewus*, day, had their origin in the name of the sun or light; for in the oriental languages, *di* is bright, splendid. It is found, with various orthography, in most languages, and must therefore have been of most ancient use. Cluver supposes this to be the *Thoth*, or *Taut*, of the Egyptians, of which I have not satisfactory evidence. But the word seems to be the basis of the name of the German deity *Tuisto*, or *Tuisco*, and of the name which the northern

* See the Lexicons of the Hebrew and Celtic languages—Mallet. North. Antiq. vol. i. 92—Asiat. Res. i. 254; iii. 387, 388. *Bhavana* seems to be a compound of *Bhava*, (Βιοω,) life, and *vana*, Venus.... vol. v. 228.

This name of Venus, *ben*, *bean*, has been supposed to be the Celtic *ban*, white. I believe the word to have had a different origin; but the Greeks may have had such an opinion; and from this opinion may have sprung the fable of the birth of Venus from αφρος, froth, whence her Greek name Αφροδιτη. And hence perhaps the Latin *Venustas*, beauty.

nations bore, *Teutons;* as it certainly is of the word *Tuesday*, in Danish *Tiisday*, or *Tysday;* in Swedish *Tisdag*. It is no small confirmation of this opinion of the origin of *dia*, or *dis*, that the Germans call *Tuesday*, *dienstag*, using *tien*, *tan*, which signifies fire or the sun, in the place of *dis* or *dia*. They use also *dingsdag*, as do the Dutch, which is evidently a corruption of the same word.*

This deity the Gauls claimed as their common father, as we are informed by Cesar. "Galli se omnes ab Dite patre prognatos prædicant; idque ab Druidibus proditum dicunt."

But *Woden*, whose name in Danish is *Odin*, was claimed by the ancient Gothic tribes as the great leader who conducted them from Asia, and to him they paid particular honors. He answers to the Hermes of the Greeks, and the Mercury of the Romans, and his name is the basis of dies Mercurii, *Wednesday*, Wodnesday, in all the Teutonic dialects.

Faber supposes *Woden* to be Noah. That Woden is the same character which the Orientals venerate under the name of *Budha*, *Bod*, *Buddo*, *Budso*, seems to be generally agreed; and *Budha*, Bryant maintains, is the symbol of the Ark. Sir William Jones suspects him to have been the great Sesac, or Shishak.†

Whether this personage was Noah, or any other real person, we may never be able to determine with certainty, as no historical records which can be deemed authentic, now exist, of a date sufficiently ancient, to dissipate the obscurity which hangs over this subject. The Cashmirians boast of his descent in their country; and Sir William Jones has attempted to show, from the Hindoo books, that this deity and his worship were introduced into India from the west, about ten or eleven centuries before the Christian era.

To throw some light on the history of this character, we may observe that in Hindoostanee, as well as in the languages derived from the Sanscrit, *Budha* signifies

* Cluver, lib. i. 26.—Mallet's North. Antiq. ch. 4 and 5.

† Faber. i. 287, 299. and ii. 95.—Bryant. vol. iii. 553.—Asiat. Res. i. 425—vi. 257—vol. i. p. 8.

wise, *wisdom*, or a *wise man*, a *sage*, or *philosopher*. In this fact all the gentlemen who have written on the history and antiquities of India, coincide. The word is found in the Malayan and Cingalese languages, as well as in Sanscrit.*

This explanation of the name may help to elucidate the history of *Budha* and *Woden*. In the Welsh language, *guybod*, is to *know* or *understand*. In the Anglo-Saxon, the word is written *gebodian*, or *bodian*, to predict, to *bode;* and every person acquainted with the latter language, knows that a multitude of words were written with or without this prefix *ge*. In the Irish language, from the Celtic stock, the same word appears in *fodh*, knowledge, skill; in *fodach*, wise; in *faidh*, a prophet, from which the Latins formed their *vates*. This orthography *fodh*, comes nearest to the Chinese *Fo* or *Fohi*, whose character resembles that of *Budha*. We know that nothing is more common than this convertibility of the letters *B*, *F*, *V* and *W;* for the Latin *flo* and the English *blow*, are the same word, in different dialects—*vicus* is *wick*—*Bios*, is *vivo*, and the Irish *fodh*, knowledge, and the English *wot*, are radically one word. Hence *Woden*, in the Teutonic dialects, like *wot*, would be the natural orthography of *fodh*, *faidh*, *vates*. We then conclude, with a degree of probability, that *Woden* and *Budha* sprung from the same parent, and represented some man of distinguished wisdom, who was first admired and afterwards deified.†

Dr. Buchanan, who has written a treatise on the religion and literature of the Burman empire, inserted in the Asiatic Researches vol. vi. makes no question that *Budha*, is the *Bod* of the Arabians, the *Pout* of the Siamese, the *Boutta* of Clemens Alexandrinus, and the same as the *Godama* of the Burmans.

The Arabians formerly had an idol named *Wudd*, and not improbably the Persian lawgiver *Mahabad*, may have

* Asiat. Res. ii. 9—vol. iii. 40—vol. iv. 221—vol. vi. 257, 260—vol. vii. 33, 34, 397.

† In Welsh, *byd;* in Irish, *budh*, *boith;* in Cornish, *byt;* in Armoric, *bet* is the world: but tho some nations have called the universe or heaven, the deity, this does not seem to be the origin of Budha, which signifies a sage.

had his name from *maha*, great, and *bad*, Bode, Budha. As *Budha* was not the primitive deity of India, and as no such deity was worshipped by the Celts, we may perhaps infer that the primitive inhabitants of India, and the Celts of Europe, separated prior to the origin of this character and his worship. It will follow, then, that the Teutonic tribes and the later Hindoos, who worshipped Woden and Budha, were later branches of the great family, who migrated from one central spot, a few centuries later than the Celts and aboriginal Hindoos. The Celtic nations used the word *fodh*, or *bodh*, in its primitive sense of *wise* or *wisdom*, which sense it retains; but the character, who, for his distinction, was called the *wise*, might not have arisen, until the Celtic tribes had migrated from the east. It is not impossible, however, that the nations in the east and west may have had different persons, who, for their eminence, acquired this title, after they had separated from each other; for among most nations have similar characters arisen, like Zoroaster, Solon, and Lycurgus, who distinguished themselves by their superior wisdom.

Thor, the thunderer of the Teutonic tribes, Parkhurst supposes, derived his name from the Hebrew verb תר, to go round, whence תור, a turn or round; and that the radical sense is the *heavens in circulation*. If this is the root of the word, the name was assigned to heaven on account of its vaulted appearance. The word may equally well be derived from the Celtic *tor*, force, elevation, grandeur, the Hebrew אור, illustrious. Whatever may be the radical word or idea, it is certain that this is the root of the Celtic *taran*, thunder, from which, by corruption, the Greeks are supposed to have formed their κεραυνος. *Thor* answers to the Jupiter of the Greeks and Romans, the god of the air; and he is probably the deity mentioned by Cesar, under the name of "Jovem, imperium coelestium tenere."*

Bor, another deity of the north, is evidently the north wind, *boreas*, of which word *Bor* is the root.

* Mallet's North. Antiq. ch. vi.—Cesar. Comment. lib. vi. 14.—*Thor*, to correspond in etymology with Jove, must be formed by prefixing an article *T'* or *th* to *ar*, *aer*, *air*.

Loke, or *Loch*, the evil deity of the north, is darkness; being nothing more than the Celtic *loc*, or *loch*, black, dark, still seen in Irish, as well as in the Chaldee לקא, obscurity.*

Frea, (or *Frigga*) was the Venus of the north, and like this goddess, her name is the appellative of *woman*, still preserved in the Celtic and Teutonic languages; in Irish, *frag;* in Welch, *uraig;* in German, *frau;* in Dutch, *vrouw.* Gebelin supposes *Frea* and the Latin *Rhea*, to be the same, and derived from the Hebrew רעה, to feed or nourish—a verb found also in the Arabic and Ethiopic. This is indeed a very obvious derivation of *Rhea*, the earth; but as Faber thinks, *Frea* is more naturally deduced from פרה, to produce, to be fruitful, the root of *pario*, and the English *bear*.†

Gebelin, in another passage, deduces this word from ראה, to see, or inspect; from which root the Egyptians, by prefixing the article *ph*, formed *phre*, the sun.‡ And perhaps from the supposition of such an origin of the word, *Rhea* may have been believed to signify the moon.

But Rhea was undoubtedly intended to signify the earth; for Hesiod informs us that Rhea was the mother of Vesta, Ceres, Juno, Pluto, Neptune, and Jupiter, which represent fire, corn, the female powers of production, the regions of death, the ocean, and the atmosphere. The earth was considered as the parent and nurse of men, beasts and vegetables; the word *Rhea*, signifies parent and nurse; and hence the mother of Romulus and Remus was called *Rhea Sylvia.* And as the earth was considered by all the ancients, as the *mother*, the female parent of productions, she had a husband assigned to her, among the physical powers of nature. Thus *Isis*, the earth in Egypt, had Osiris, the sun, for a husband; Rhea, the earth in Greece and Rome, had for a husband,

* Orient. Coll. ii. 234—Mallet, ch. vi.

† Faber. i. 143.—Gebelin's Hist. of Hercules, vol. i. p. 205.—Mallet's North. Antiq. ch. vi.—Parkhurst & Ludolf's Lex.

‡ Gebelin, vol. iv. 42, 43.—The Celtic orthography *frag*, *uraig*, corresponds with *frigga;* the modern German and Dutch words correspond with *Rhea.*

Saturn, or time. In the same manner, *Ops*, another name of the earth, had Saturn for a husband.*

That this word *Rhea*, ריה is the root of *Frea*, the Venus of the north, I will endeavor to prove, or at least to render probable, by citing an analagous fact, which shows how extensively the opinion, that the earth was the *mother* of all productions, prevailed in primitive ages, and which unfolds the origin of the word *mother*, in its different senses, which has hitherto been unexplained.

In a passage of Sanchoniathon, preserved by Eusebius, the historian informs us that in the creation of the world, the spirit, operating upon chaos, produced Μωτ, mōt, which the author explains by *mud*, a putrid mass of wet earth, from which were created intelligent animals, men, the sun, Vulcan, and his son Adam.†

Plutarch informs us that the Egyptians called Isis, *muth*, which signifies *mother*. Macrobius writes that Osiris is the sun, and Isis the earth. Jablonski and Kircher agree that *muth* is the surname of Isis. Tacitus informs us that the Germans worshipped *Herthum*, that is, *terram matrem*, mother earth.‡ The scriptures also inform us that man was made out of the dust or earth.

* Hesiod. Theog. *v*. 453.—Lempriere under *Rhea* and *Ops*.

† See the observations of Bochart on this passage of Sanchoniathon....Phœn. lib. ii. ca. 2. This author states, that in the beginning there was πνοην αεροσ ζοφωδυς—a spirit of dark air, which he calls χαος ερεβωδες, a chaos of Erebus or darkness. "And darkness was upon the face of the deep"....Gen. i. 2. All ancient authors seem to have had similar ideas. See Hesiod. Theog. *v*. 123.

Εκ χαεος δε ερεβος τε, μελαινα τε Νυξ εγενοντο.

From chaos sprung Erebus, and black night.

Says Sanchoniathon, εκ του αυτου συμπλοκης του πνευματος εγενετο μωτ; τουτο τινες φασιν ιλυν, οι δε υδατωδους μιξεως σηψιν. From this connection of the spirit was produced *mōt*, which some call clay or slime, and others a putrid moist mixture.

‡ Plut. de Iside. Not having Plutarch to consult, I cite this passage from Cluver. Germ. Antiq. lib. i. ca. 27. See also Macrobius. Saturn. lib. i. ca. 21. Tacitus. de Mor. Germ. 40. The authorities of Jablonski, Kircher and Macrobius are cited at second hand. It has been already remarked that *Isi* is still in Coptic the name of the earth. And see Parkhurst under עש.

This ancient Egyptian word *mot*, from the root *mo* or *muo*, water, from which the Greeks formed their μυδαω, the Latins their *madeo*, and the Welch their *muydo*, to wet or moisten, we retain almost unaltered in the English word *mud*, wet earth. And in conformity with the universal opinion of antiquity, that the earth was the parent of productions, nations have formed on this root, *mot*, *mud*, the words *matter* and *mother*—*matter*, the *material*, out of which things are formed—and *mother*, the female parent of beings. Hence the Greek ματηρ and μητηρ; the Latin *mater;* the Dutch *moeder;* the German *mutter;* the Swedish *moder;* and Irish *mathair*, a female parent. Hence the Latin *materies*, matter, material, that out of which any thing is formed. But what is remarkable, we retain the original sense of the word, that of a moist slimy substance, as in vinegar, in the English word *mother;* the Dutch *modder*, mud; the German *moder*, mud, mold; and in the Celtic Irish, *mathair*, gore, *matter*. Equally remarkable is it that the word *matter* retains the sense of *pus*.

This singular concurrence of facts demonstrates the truth of history, in regard to the opinions of men in early ages, concerning the origin of things; and in my apprehension, goes very far to prove the real existence of the Phenician historian, Sanchoniathon. It proves also the common origin of the Egyptian, Celtic and Teutonic languages; and accounts for the common origin of the goddess *Rhea* and the *Frea* of the north—the word which signified the *earth*, the parent of production, being applied to a *female* of the human race, in a like character.

Certain it is that the mythology of the Celtic and Teutonic nations, who were unquestionably the ancestors of the Greeks and Romans, was essentially the same, as that of their descendants in Greece and Italy. The names of their deities were, at least in many instances, different; but their characteristic powers and offices were the same. Of this fact we have full evidence in the brief account which Cesar has left, of the deities of Gaul:—"Deum maxime Mercurium colunt: hujus sunt plurima simulacra: hunc, omnium inventorem artium ferunt; hunc, viarum atque itinerum ducem: hunc ad quæstus pecuniæ mercatusque habere vim maximam arbitrantur. Post hunc, Apollonem, et Martem, et Jovem, et Minervam. De his eandem ferè, quam reliquæ gentes, habent opinionem. Apollonem, morbos depellere; Minervam, operum atque artificiorum initia transdere; Jovem, imperium cœlestium tenere; Martem, bella regere."*

The deity they chiefly worship is Mercury; of him they have many statues or images; they consider him as the inventor of all the arts, the protector of roads and journeys, and believe him to possess a peculiar faculty of acquiring property by commerce. After him they revere Apollo, Mars, Jove, and Minerva. Concerning these deities, they entertain nearly the same opinions as other nations. They believe that Apollo drives away diseases; Minerva introduces the knowledge of arts and manufactures; Jove presides over the atmosphere or visible heavens; and Mars governs the affairs of war.

In this account of the origin of the pagan deities, I have some confidence, because it is very simple and natural; because it accords with the known taste and genius of man, whose imagination, especially in a rude unsettled state of society, is disposed to personify natural objects—and particularly, because the etymologies explain directly, and without any forced analogies, the principal characters and offices of the deities. The great source of error, among writers on this subject, has been, their reliance on the explanations or opinions of ancient authors, who wrote their accounts a thousand or fifteen hundred years after the origin of the deities, when the knowledge of the original signification of their names was lost, and when the ignorance and fancy of men had engendered innumerable fables on this subject, confounding the characters of the gods, and disguising the simple truth with a complicated and monstrous mass of fictions.

These etymologies prove further the antiquity of the Celtic races of men; as the names of the pagan deities are mostly found in their language. It is a fact yet susceptible of proof, that the ancestors of the inhabitants of the west of Europe were coeval with the first inhabitants

* De Bel. Gal. lib. vi. xiv.

of Syria and Egypt; and that they originally spoke one language.

I shall close this sketch of the history of Pagan Mythology, with some account of the origin of the name God, in German *Gott.*

In the ancient Persian, *Codai* signified *Lord*, or *seigneur*. Now we find in Hesiod a demi-god or giant, named *Cot*, Κοττος, *Cuthus*, who was one of the sons of Coelus and Terra.

> Αλλοί δ' αυ γαιης τε και ουρανου εξεγενοντο,
> Τρεις παιδες μεγαλοι και οβριμοι, ουκ ονομαστοι,
> Κοττος τε, Βριαρεως τε, Γυγης θ' υπερηφανα τεκνα.—

There were born of Coelus and Terra, three sons, great, mighty, and of indescribable fame, Cottos, Briareus, and Gyges, an illustrious progeny.*

It is well known that Hesiod is the most ancient, or one of the most ancient of the Greek authors, whose works are now extant; and his placing *Cottos* among the fabled giants, indicates that this character was of the highest antiquity. We hear of the same character in Herodotus, the most ancient Greek historian. In speaking of the names given to the three great divisions of the earth, he says that many of the Greeks alledge *Asia* to have been named after Asia, the wife of Prometheus. But, he observes, the Lydians contradict this, and assert that Asia was so called from *Asias*, a son of *Cotys*, and grandson of *Manis*.†

This is a remarkable fact; for all ancient nations appear to have retained traditions respecting *Manis* or *Man*, the first of the human race; altho these traditions are somewhat confused.

From the veneration paid to this illustrious character, the name became a common title of princes in Persia, Armenia and Thrace, the very countries through which the Teutonic tribes can be distinctly traced in their migrations to the western parts of Europe. Livy mentions a *Cotys*, king of the Odrysians in Thrace, in the Consulship of P. Licinius and C. Cassius, in the sixth century of Rome. The same author mentions a *Cotto*, a Bastar-

* Hes. Theog. line 147.—Orient. Coll. i. 94.

† Herod. in Melpomene, ca. 45.

nian of distinction, in the Consulship of Quintus Fulvius and L. Manlius, in the same century.*

Strabo mentions *Cothus* among the names of distinction which were in use among the barbarians of Thrace.†

Tacitus, in the second book of his Annals, gives an account of *Cotys*, a king of Thrace, in the reign of Tiberius; the same prince to whom Ovid addressed a letter, while in exile at Tomos.‡

A prince of the same name is mentioned by Tacitus, in the reign of Claudius.

Tacitus also mentions a *Cotys*, a king of the lesser Armenia, about the middle of the first century of the Christian Era.§

In the reign of Augustus, a prince named *Cottius*, governed a country on the Alps; and a particular ridge of those mountains, under the name of *Cottian*, long preserved the history of the prince and his dominion.‖

Cluver informs us that the Persian name of the Supreme Being is *Chod;* but I question his inference that this is the *Thoth* of the Egyptians. I take the Persian *Chod*, to be the German and English *God;* the *Godama* or giant *Goda*, of the Burman Empire; and perhaps all the titles of princes before mentioned, were derived from a common source.¶

This word, without the Greek termination, *Cot*, *Chod*, *God*, or *Got*, seems clearly to have descended from the *Cothus* of Hesiod, or *Cuth*.

Dionysius, the geographer, in a passage cited by Pellutier, relates that the Phenicians called *Gadeira*, Gades, now Cadiz, *Gottinhus*, the house of *Goden*. The primitive inhabitants called it *Cotinusa*, the house or temple of *Cotys*.**

* Liv. lib. xlii. 29---lib. xl. 57.

† Strabo, lib. vii. ca. 7.

‡ Tacit. An. lib. ii. 64, 66----Ovid. Epis.

§ Tacit. An. lib. xi. 9----lib. xii. 18.

‖ Strabo, lib. iv. ca. 1---lib. v. ca. 1---D'Anville, vol. i. 55---See Lempriere under the word *Cotys*, and the authorities cited.

¶ Cluver's Germ. Antiq. lib. i. 26.

** Pelloutier. Hist. des Celtes. i. 15.

The Hindoo books mention *Cudha*, a distinguished legislator of antiquity, and *Khoda*, in India, is a name of God.*

Now we observe in the names of ancient Assyrian princes, a syllable which is evidently the same word; as in *Ched*orlaomer, Nebu*chod*nosor, Nebu*chad*nezzar. *Nebu*, signifies *high, elevated;* being the *Nebo*, a mountain, mentioned in the Scriptures, and the root of the Slavonic *Nebesi, Nebesech*, heaven. *Nezzar*, I take to be the Hebrew נזר, a guardian. The *omer*, in *Chedorlaomer*, is the Hebrew אמר, a word, a *command*, the root of the Turkish *Emir*, and the English *Amiral*, now *admiral;* a word preserved in the Walde*mar* and Cass*imir* of Northern Europe. *Nebuchadnezzar*, then, signifies the *high lord*, the *guardian;* and *Chedorlaomer* contains two words signifying *lord*, and *commander*.

Of the origin of this word *Cotys, chod, Khoda*, the following is the most probable account. In the Celtic language, *cuth*, signifies the *head*. This is the root of the Saxon *Cyth, Cyththe*, knowledge, science; *cythan*, to make known, to testify; and *cyther*, a witness. The Latin *testis*, a witness, is formed, by a like analogy, from a name still retained in the Italian *testa*, the *head*, also wit, judgment; which the French have contracted into *tête*.

This *cuth*, the head, is unquestionably the Hebrew קד, to bow the head, and the modern Turkish *Cadi*, a judge, whence the Spanish *alcaid*. The Mongolian Tartars retain the same root in their *Khodsha*, a sage, which seems to be a compound of *Chod* and *shah*, a prince.†

From the same root unquestionably was formed the Hebrew קדם, which, as a noun, signifies *priority, precedence*, and as a verb, *to go before, to precede*. By an easy analogy, it signifies also the *East*, the place of the rising sun. The same word, in like senses, is, in the Ethiopic language, *Kadem, to go before, to be first*—also *priority, beginning*.‡

From this word, I presume, the oriental nations receiv-

* Asiat. Res. ii. 32—Grellman on the Gipseys, p. 173.

† Tooke's Russian Empire, vol. i. 409.

‡ Ludolf's Lex. col. 214, 215.

ed the title of their *Godama*, or *Goda*, who is the deity of the Burman empire.

It should be added that the name *Goda* was used in the north of Europe, as the name of distinguished personages, when the Danes invaded England in the tenth century. In the Saxon Chronicle, a Danish Thane, of this name, is mentioned under the year 988.

The only doubt respecting this origin of the word *God*, arises from the common orthography of the Teutonic words, *good* and *God;* for in Saxon, the orthography is the same—*god;* and in Gothic, *goda* is good. The English word *good*, is generally supposed to be the Greek αγαθος, without the terminating article αγαθ; and Lye, in his Dictionary, remarks, that as the same word signifies *God* and *good*, so in Saxon, the same word signifies *man* and *evil.* Equally remarkable is it that the word *bog*, which, in the Slavonian languages is the name of the Deity, in the Amharic dialect of Ethiopia, signifies *good.**

The word *good* is very naturally deducible from the Hebrew עדן. Oden, or Eden, signifying *pleasure, delight*, the Greek ηδονη; for it was not unusual for the Orientals to pronounce the first letter of this word with *g*, *goden;* and this orthography corresponds with that of the word before cited, *Gottinhus*, the house of *Goden.*

These are the principal facts and authorities which I have found respecting the origin and history of the name under which Christians worship the Supreme Being.

Names are of little importance, if the ideas communicated by them are correctly understood. Yet it may be suggested, that in the translation of the Scriptures from the Hebrew, it might have been expedient to retain, in the version, the original word, JEHOVAH. This word, which is from the Hebrew verb, to *be*, to *exist*, and which imports *self-existence*, or, by way of eminence, *the Being*, the *universal existence*, is the most express-

* See Lye's Sax. and Goth. Dict. under *man.* Ludolf's Amh. Col. 43. Cluver's Germ. Antiq. i. 25. The *bog* of the Russians, and *bogo* or *bago*, of the Ethiopians, seems to be the root of *Bogud*, a prince who assisted Cassius in the war in Spain. "Paucis diebus, litteris Cassii acceptis, rex *Bogud*, cum copiis venit."... Hirt. Pansæ De Bel. Alex. 49.

ive term that can be found in any language, to describe the nature and character of the incomprehensible Creator, and Governor of the Universe. *Jehovah Aleim*, the Hebrew words which frequently occur in the sacred writings, denote the ALL-COMPREHENSIVE, SELF-EXISTENT BEING, the SOVEREIGN LORD of the UNIVERSE. They convey the most sublime ideas which the human mind can conceive, of transcendant essence, power and majesty; and no pious man can pronounce them, without feeling a sentiment of the deepest humility and reverence.

ERRATUM.

IN page 64, line 26, for *nivis*, read *nix*.

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A DISSERTATION

On Chronic Debility of the Stomach.

BY BENJAMIN WOLSEY DWIGHT.

THE following observations were read before the Academy, as far as the close of the remarks on Acidity of the Stomach, at their meeting, June 26, 1810; and the remainder at their next meeting, on the 23d of the succeeding month.

The author, having been engaged but a little period, in medical pursuits, is not extensively acquainted with what may have been written by others, on the same subject. He has no where seen it discussed in a manner, which appeared to him satisfactory. As he has suffered severely from the disease, during the last eleven years of his life, he was induced for his own satisfaction, and from a wish to benefit others, to commit to writing, the result of his experience and observation. As many of those, who may read this work, may be presumed to be to a great extent unacquainted with subjects of this nature, it was proper, in his opinion, to make several explanations, which would have been unnecessary, had they been addressed to a Medical Society. Some things also, have been cursorily noticed, or wholly omitted, which would have appeared, had they been intended for a work professedly medical. He has been led to be more minute in many parts of the discussion, also, from the fact, that the disease is becoming yearly more frequent. Among our ancestors it was but little known. They all, except a very small number in a few towns, were accustomed to much bodily exertion. There were few or no pleasure carriages in most parts of the country. Both men and women almost universally rode on horseback. Professional men as universally had farms. The mechanics, whose employments were of a sedentary nature, busied themselves about agriculture, also, to a considerable extent. Now, the disease is spreading extensively. Multitudes of clergymen, of mechanics, of students at colleges, and of women, are losing their health from this cause. Clergymen have no farms; Mechanics, from the increasing division of labor, are in the same predicament. A large proportion of both these classes of persons, and many others, have in a great measure ceased riding on horseback. At the outset it is less fatiguing to ride in a carriage. When exercise must be taken, the inquiry seems to be, What kind will excite the least weariness? not, What will most promote health? It is laughable as well as melancholy, to hear the sons of farmers, as soon almost as they have entered on a studious course, and mechanics, by nature sturdy, complaining piteously of the hardships of any employment which requires certain bodily exertions, to which they are unaccustomed. Females, to a great extent, are becoming dyspeptic from dress, from diet, and from want of exercise. The effects will be more evident and distressing in the next and succeeding generations.

THE stomachs of all animals, though they may differ in many respects in the different species, agree in this, that they are concerned to an important extent, in the process of digestion. Some animals live wholly on animal food; others wholly on vegetable; while man is fitted to live on either kind, but more happily on a due mixture of both. The digestive powers of different men, are often exceedingly different, in various respects, and even of the same individual, at different periods of his life, so that what is healthful at one period, is noxious at another. Thus, a person debilitated by a fever cannot bear the food, which, in health, is wholly mild and grateful. On a sound state of the stomach, no small part of our comfort, and energy of body and mind, depend.—If the digestion is vigorous, the animal motions are usually pleasant, the secretions and excretions regular, the spirits cheerful, the body attains its utmost strength, and the mental powers are capable of being exerted to the highest advantage. There are persons constitutionally dull, stupid and phlegmatic, who possess great vigour of body, and a rapid digestion. To these, the above observations are not strictly applicable. So important an influence has a sound digestion upon the whole state of the body and mind, that many Physiologists have very properly styled the stomach *the laboratory of the system.*

The immediate cause or instrument of digestion is the same in all those animals with whose structure and economy we are thoroughly acquainted, though the steps preparatory to this process are in many instances exceedingly different. Thus in the Gallinaceous Class of Birds the latter process is the result solely of maceration and muscular action; while in man and many other animals it is performed by the action of the teeth, aided by the operation of the saliva. But the digestive process so far as it takes place in the stomach, is accomplished chiefly by the gastric liquor. Some aid is, however, rendered by the muscular action, and heat of the stomach; and the process is completed in the duodenum, by means of the solvent and saponaceous powers of the pancreatic liquor, and bile.

The Gastric Liquor possesses some very singular and very important properties. Its solvent or corrosive power is totally unlike that of any other fluid, with which we are acquainted. It not only dissolves every species of food suited to the sustenance of man, but also the stone in the bladder, and some other substances of an equal or greater density; while it produces no corrosive effect upon several kinds of worms, which not only often live, but grow rapidly, in the stomachs of men, and many other animals. Neither does it produce any corrosive effect up- the stomach which secreted it, while the living principle remains; but, when the living principle has become extinct, especially if the person was previously in health, its corrosive effects are in some instances so powerful, as to eat through all the coats in a few hours. It possesses, also, powers eminently antiseptic, or opposed to putrefaction. Were it destitute of this property, the food taken into the stomachs of the sick and debilitated would, in many instances, become putrid, and destroy life. The same degree of heat, which is ever found in the stomach in health, aided by the same quantity of air and moisture, out of the stomach, will occasion all the substances which we use for food, to putrefy in a few hours.

The time requisite for the due performance of the digestive process is very different in different animals.—Some substances, also, require a longer time than others to undergo this process; and individuals of our species differ not a little in the strength and activity of their digestive powers. Some animals can live with little or no apparent inconvenience, a considerable period, without fresh supplies of food. Bears are said to remain, in many instances, through a large part of the winter, in this situation; and I have been informed of a Wood Hatch, which continued more than two months in a torpid state, in the winter season; but on being brought into a warm room, became after a little period, active and sprightly, and continued perfectly healthy. Some species of insects and reptiles are known to live many months, and probably years, in a similar situation. To our species, it seems to be almost universally indispensable to the enjoyment of good health, to take food, once or oftener, every day. Digestion is, also, not a little influenced by various extrinsic or adventitious causes, such as the quality of the food; a redundant or deficient quantity; the good or ill preparation of it by coockery; and a due degree of mastication, or the want of it. On these subjects, though they furnish room for copious and interesting remarks, I cannot in this place dwell. Some observations concerning them, I shall make in the sequel. These and other causes may vary the time requisite for the due performance of the digestive process, in different persons, and in the same person, at different times; but, in most healthy people, it is completed at some period between three and six hours, from the reception of the food into the stomach.

To a person in high health, or possessing what is termed *a good stomach*, no directions are generally necessary. The appetite is here usually the directress. But to one, who has the misfortune to possess a stomach permanently debilitated, a train of evils commonly ensue, sufficiently distressing to make any information on the subject interesting.

On this disease, viz. Permanent or Chronic Debility of the Stomach and Intestines, I propose to offer some observations. The Stomach I believe to be, originally, the seat of the disease; but from the intimate connection between it and the Intestines, by means of nerves, blood vessels, continuation of membrane, and similarity of structure and offices, they appear to be drawn in, in a greater or less degree, for their share of suffering. That the Oesophagus is affected in a similar manner, I have seen no proof.

Few diseases to which the human body is liable, and which do not immediately endanger life, are so distressing to the patient, or give rise to so great mistakes in his mind, and in the minds of ignorant physicians, as to their nature and probable consequences, as that which is proposed for consideration. To all such physicians there is, by the common consent of mankind, an admirable retreat provided, in which they may happily intrench themselves; a retreat, to which physicians of a superior character are often accused of resorting, viz. calling all those diseases, of the nature and causes of which they are ignorant, by the magical name *nervous*. Bestowing this name upon a disease, often removes many fears from the mind of the patient, and has no small effect in satisfying him, when little or nothing is done towards removing his sufferings: for it seems to be admitted, by common consent, that it is unreasonable to require of a physician that he should be able to cure, or even that he should understand any thing relative to the nature of, a nervous disease. Persons laboring under a Chronic Debility of the Stomach, though their sufferings may be very severe, and long continued, are generally believed by those around them, to possess crazed imaginations, and to be diseased in mind merely; and all, almost, are ready to join in the laugh at their whims, and to become impatient of their complaints.

The wise and the foolish, the learned and the ignorant, the old and the young, men and women, all unite in deciding peremptorily on a subject which they have never investigated. They experience no such troubles themselves, and therefore they conclude that they are not experienced by others. They hesitate not to determine, that the great bulk of dyspeptic persons are a poor, spiritless, moping race of beings, the subjects of unceasing mistakes, nearly bereft of their reason, and fitter for bedlam than for the company of persons so cheerful, knowing, and elevated above whims, and fears, and prejudidices as themselves. It is easy to say, "We are the people, and wisdom shall die with us"—and equally easy when pressed in an argument to shout aloud, "I have gained the victory;" but it is a very difficult thing, when no proof is presented, to convince those who have thoroughly investigated any subject under discussion, of the truth of these assertions. An ignorant and prejudiced man will often rest immoveably satisfied that he needs no additional light to discover any truth. If a person is laid prostrate with the Yellow Fever, or the Pleurisy, it will be readily admitted that he is really sick; but he who labors under Chronic Debility of the Stomach, will meet with no compassion.

It is by no means my intention to say every thing that might be said, relative to the disease under consideration. For this purpose a volume would be necessary. I propose only to mention such things as have fallen within my own experience and observation, and such reflections as have grown out of them. The cases, which will be cited in proof of various opinions to be brought forward in the sequel, are partly such as occurred to me during about twenty months, while I was employed as a medical practitioner, viz. from July 1803 to March 1805. Some of them have fallen under my observation since that time. I mention this as an apology, for the want of particularity, which may be observed in the descriptions of some of them. The facts are all stated from recollection, none of them having been committed to writing at the time. I shall mention nothing, however, of which I have not a distinct remembrance.

The Seat of the disease has by some persons been confined to the *nerves* of the stomach, and by others to the *muscular fibres*. It appears to me that both are not a little affected, and also that the blood vessels, and their appendages, viz. the vessels which secrete the mucus that defends the inner coat of the stomach, and those which secrete the gastric liquor, together with the membranous and villous coats, all come in for their share.

That the nerves in this disease have experienced a loss of tone, is evident from many considerations, particularly from the many remarkable morbid sympathetic actions, to which it frequently gives rise, in many other parts of the body. On the existence and variety of these morbid sympathies, I shall have occasion to enlarge hereafter. Admitting their reality for the present, I observe, that the nerves appear to be necessary to the existence of sympathetic action. Destroy one of the large nerves, and that part of the body which receives its nervous influence from it, will immediately become destitute of sense and motion. Facts in support of this assertion, have been often stated by others. It may not be amiss, however, to state the following case.

In the summer of the year 1804, I was called from a distance to visit a lad, aged about 14 years, who had fallen a few weeks before from a tree, thirty-six feet, upon a pile of stones. On my arrival I found him lying in a bed, and unable to move his legs or his body. A more minute examination exhibited a very large wound, directly over the spine, a little below the lower part of the neck. The precise state of the injury, owing to the tumefaction, and soreness, and the extreme pain which a change of posture occasioned, it was difficult to ascertain. I became however soon convinced of what I before could hardly doubt, that irreparable injury had been done to the Medulla Spinalis. After making such an examination of his state and circumstances as seemed necessary, a pin was repeatedly thrust about a quarter of an inch into various parts of his legs, without his making the least complaint, or even suspecting what had been done. A lighted candle was also held to his feet a sufficient length of time to have occasioned, in a healthy person, severe pain. Of this, too, he took no notice; yet the wound was exquisitely sensible. His mind, also, was active; he was able to converse without difficulty, and to eat his food with tolerable ease. He had no command over the

Sphincter Ani, and Sphincter Vesicæ muscles, but his fœces and urine passed without his knowledge. The spine was doubtless fractured, and such a degree of pressure had been made on the Medulla Spinalis, as wholly to destroy sensation and voluntary motion in all those parts of the body, which derived their whole supply of nerves from that part of it below the wound.

That the morbid sympathetic actions in question, are the result of nervous influence, is further evident from the fact, that certain violent stimuli taken into the stomach, greatly derange or destroy voluntary motion, before they can have entered the blood. Toad Stools taken into the stomach produce, in many instances, the most alarming and deleterious effects, without producing any inflammation in its coats, as is usual from arsenic, and other metallic poisons. Neither is there any reason to believe that the blood undergoes any change; yet the head, and the whole muscular system are sometimes greatly affected, to such a degree as to produce death. If the Toad Stools, after having begun to disorder the patient, are thrown off from the stomach by vomiting, a speedy and perfect recovery usually ensues.

The same truth might be further evinced from the operation of opium, upon the whole system, when taken into the stomach, or injected per anum. The effects of severe study, or close application of the mind upon the debilitated stomach, can be accounted for on no other principle.

That the muscular coat of the stomach is, also, in part the seat of the debility in question, appears highly probable, if not certain, from the following considerations.

In frequent instances at the commencement of the disease, and for a considerable period afterwards, and at times throughout its whole continuance, till it terminates in death, or till health is restored, especially in delicate young ladies, the stomach becomes so extremely irritable, as daily to reject by vomiting, a very large portion of the food which it has received, and such as was formerly, when in health, wholly easy and pleasant.

The contractions of the muscular fibres are here irregular, unnatural, and inclining towards or becoming spasmodic, and of course the fibres themselves are debilitated.

In other instances, a powerful torpor of the stomach takes place, and the contractions of the muscular fibres are so feeble, that the alimentary mass, even when in a state of rapid fermentation, and already highly offensive and sickening, remains as a dead weight, incapable for a time of being thrown off. There is so little excitability left, that even this unnatural and offensive stimulus will not occasion vomiting. This state of the stomach I have often witnessed, and in such persons, when the stomach is free from this fermenting mass, powerful emetics will have little more effect, as I know from repeated trial. Neither is there in such cases, sufficient strength remaining in the muscular fibres, to force the alimentary mass through the pylorus, except in a very slow and imperfect manner. I have frequently known it to remain many hours and even days upon the stomach, after it should have been thrown off.

That the other coats are similarly affected appears probable, from the fact that such an intimate connection subsists between them, that we can hardly conceive of the one being disordered, without producing the like effect upon the other. Analogy lends some aid in support of this suggestion. Thus when one eye is afflicted with pain, or inflammation, or permanent debility, the other is often in a little time affected in a similar manner, and apparently from no other cause, than the intimate connexion or sympathy which exists between the two. Is it not reasonable to believe that the connexion subsisting between the coats of the stomach is far more intimate than between the eyes? Should it be said that it is difficult to conceive how a membranous coat should become the subject of debility, I answer, that it is equally difficult, previous to experience, to conceive how a membrane, which is usually apparently insensible, should be capable of inflammation, and when inflamed should be sensible to a very exquisite degree. That this often occurs, no one will deny.

That the blood vessels, and their appendages the secreting vessels, partake of the debility under consideration, appears probable from the altered nature of the secretions. On this subject I cannot now enlarge, without anticipating what I have to say elsewhere. In vessels so small as the arterial and secreting vessels of the stomach, and removed at some distance in consequence of their minute ramifications, from the propelling power of the heart, is it not reasonable to suppose, that the force of the circulation depends considerably on the contractile power of the arteries, and that as the coats are debilitated, the contractile power of the arteries will be lessened? An increased local action in the blood vessels, and an increased circulation of blood takes place in every phlegmon. Why may not the contrary phenomenon occur?

To all these arguments, analogy lends some aid. That a local nervous debility takes place in some instances in other parts of the body, without affecting the rest of the system, unless by sympathy, will not, I suppose, be disputed. That a similar muscular debility also takes place, will probably be admitted. That a languid circulation of the blood may take place locally, while the general circulation is regular, seems to be admitted, with respect to the liver; why may they not all take place in the stomach?

Several respectable physicians, with whom I have conversed, have believed that the disease, commonly passing under the names Dyspepsia and Hypocondriasis, has its seat in the liver; or, in other words, that a morbid state of that viscus is the cause of it. This opinion appears to have been admitted without sufficient evidence, and chiefly, or solely, as I suppose, on the authority of some great names. In hot climates a schirrous liver is said to be a frequent complaint, as is also an acute and chronic inflammation of the same viscus; and in temperate climates very luxurious living sometimes occasions a morbid state of the liver. But these causes do not operate, except in a small degree, in this part of the United States. Among almost all the cases of Chronic Debility of the Stomach which I have seen, and they have been pretty numerous, there has not appeared to me any reason to believe that the liver was affected at all, except in consequence of the morbid state of the stomach, and from sympathy with that organ. In all such cases it is probable that the circulation of the blood in the liver is languid, the blood itself thin and watery, and the bile which is secreted less stimulating and pungent, than is requisite to excite a due degree of action in the intestines. That the stomach is primarily and the liver secondarily affected, in most cases, seems probable from the fact, that the morbid sympathies to which this disease gives rise, in other parts of the body, are all owing to the state of the stomach, and none, so far as I have observed, to the state of the liver. I would remark further, that in those cases of the disease, which I have had an opportunity of examining at their commencement, and where in progress of time some reason appeared to apprehend a morbid state of the liver, the stomach uniformly appeared to me to be first diseased.

The Causes of Chronic Debility of the Stomach are of two kinds, viz. those which operate immediately upon the organ itself; and those which act indirectly, by debilitating the body universally, or certain parts of it.

Those which operate immediately upon the stomach are,

1st. Improper Diet.

Under this head may be placed luxurious living, or the habitual use of highly delicious food; a very abundant use of sweetmeats and spices; an habitual and free use of tea and coffee, drunk too strong or too hot; ardent spirits; low living, or a diet not sufficiently nourishing; in the latter way I have known one person, possessing originally a fine constitution, and alway having every advantage for good living, who brought on the disease, to a severe degree. Strong Tea and Coffee are causes of no small efficacy, in this country. Very luxurious living, though less general in this part of it, is a cause of some magnitude; but far the most powerful of all, is the immoderate use of ardent spirits.

2. Gluttony, or eating an immoderate quantity of food.

The stomach becomes in consequence of this indulgence unduly extended, and the gastric liquor is not furnished in sufficient quantity to dissolve it.

The muscular coat and the secreting vessels thus become weakened; the food remains too long in the stomach, or is forced in a crude state into the intestines.

3. Tobacco, and other narcotics.

Tobacco, whether smoked or chewed, operates in two ways; by its narcotic effect, in lessening the tone of the stomach; and by the waste of saliva. Opium produces very powerful narcotic effects, and together with Tobacco, is a frequent cause of distressing and long continued dyspepsia. The worst case of the disease I ever met with, was produced either wholly or chiefly, by the abundant and daily use of Opium.

4. An immoderate use of sugar, acids, and various crude substances.

5. A very frequent use of certain medicines.

Some persons are ready on all occasions when indisposed, however slightly, to resort to medicines for relief, and generally to those of a very active kind. I know a sturdy mechanic, who, in consequence of costiveness, induced by a too sedentary life, resorted to *Lee's Pills*,* (a drastic cathartic) for relief. Their operation was certain, and it was cheaper at the outset than to apply to a sensible physician; hence they were continued, till after taking about *eighty* boxes of them, the stomach and intestines became so torpid, that an evacuation could not usually be obtained without similar aid.

6. A cause intimately allied to this is the improper medical treatment of acute, and also of certain chronic diseases.

A gentleman some years ago was seized in the month of August with a low fever. Two physicians, under whose care he was placed, seemed to suppose, that most diseases were owing to "*a vast mass of morbid matter as black as tar, accumulated in the intestines.*" They accordingly drenched him for several weeks, with powerful doses of Calomel and Jalap, Scammony, Gamboge, &c. In this manner they thoroughly abraded his intestines, and so far destroyed their tone, that for many months he was afflicted with the most distressing costiveness, a loss of appetite, and general debility. The In-

* A patent medicine sold in great quantities in Connecticut.

testinum Rectum he was unable for a long time to retain, but it slipt down on the least exercise, and after every stool; his mind also became greatly enfeebled. In this state I saw him. After two or three years he recovered.

A very celebrated quack whom I knew, was accustomed in certain chronic diseases, to administer one hundred and fifty or two hundred Emetics, to a patient in a single year. That death was the consequence in many instances, I have no doubt.

The causes which operate *indirectly* in producing Chronic Debility of the Stomach, are all such as tend to weaken the body universally.

Under this head may be placed,

1. A severe attack of some acute disease. The effect of such an attack, it is well known, is not unfrequently to debilitate the whole body greatly, and the stomach peculiarly. I have known several persons, who, in consequence of severe attacks of the yellow fever, had their stomachs weakened to such a degree, that a long period of time elapsed before they were restored to their usual state of health. The debility of the stomach however, in these cases was, I acknowledge in my own opinion, owing in part, to a direct action upon it. To explain my meaning I would state, that the yellow fever is in my opinion a stomach disease, owing to morbid miasmata received into it, by means of admixture with the Saliva; and that to this cause is owing the excessive and very peculiar irritability of that organ, so often witnessed in that disease. The stomach appears to be the primary and principal seat of the disease, and to *draw other parts of the system by sympathy*, into a state of morbid action. In this way, only, could I account for the extreme debility of the stomach, which I have witnessed in some of the survivors. In other cases, as in severe inflamations of the lungs and liver, the part primarily affected often never regains its former strength.

Other diseases, which do not act peculiarly on the stomach, often occasion in it distressing debility, by the effect produced on other parts of the body. I could easily cite instances, were it necessary, to prove the assertion.

2. A sedentary life. With this cause, several others are often united, which not a little enhance the evil; such as great Indolence, certain mechanical employments, and daily exposure to an impure atmosphere.—Women, who take little exercise, often suffer greatly from this cause; and many, whose daily employments induce great weariness of the legs, scarcely exercise at all, out of doors. Clergymen, Lawyers and Students, generally, suffer from the same cause. Among the mechanical employments injurious to health, or in other words inducing nervous debility, are those of Goldsmiths, Tailors, and Shoemakers. The two latter classes are usually confined during the winter, in warm rooms, heated by close stoves, and all, when at work, commonly sit in a bent posture. Shopkeepers and Clerks, from long confinement to their shops and writing desks, often become dyspeptic and sickly. There are are other mechanical employments which are common in some countries, and far more prejudicial, than those which have been mentioned, but which, being scarcely known here, I have not thought it necessary to mention particularly; such are all those, which require a frequent exposure to metallic fumes, and several of those which are carried on in large manufactories.

3. The excessive gratification of venereal desires.

4. Intense study, or application of mind.

5. The indulgence of evil passions, such as jealousy, envy, hatred, &c. Grief and fear, and excessive joy, are also highly debilitating, and particularly to the stomach. I have known some persons, possessed of great strength of body, and rigid fibres, who have injured themselves, not a little, by the indulgence of evil passions. Their stomachs at times, become thus debilitated, to a considerable degree, and permanently, and during a paroxyism of passion, suddenly filled with wind and acid.

We come next to consider THE SYMPTOMS by which Chronic Debility of the Stomach may be distinguished. By the term *symptoms*, we are to understand, the various discernible effects, which the disease occasions in the stomach and in other parts of the body.

The symptoms of this disease are of two kinds, those which affect the stomach and intestines, and which may be termed primary; and those which effect other parts of the body, from sympathy with the stomach.

As the sympathetic actions of the system have appeared to me, when present at the prescriptions of physicians, to be usually, not sufficiently brought up to view, in forming opinions of the nature of diseases; and as many of the observations yet to be made will, unless such sympathies exist, be irrelevant, I shall, before I particularize the symptoms, make some brief remarks, relative to that subject. These remarks are intended to illustrate two points, viz. that a general sympathy exists between all parts of the body; and that a peculiar sympathy exists between the stomach and other parts.

That a general sympathy pervades the body is evident, from the following considerations.

1. Obstinate bleedings at the nose, and many other hemorrhages, may be often almost immediately stopped, by the application of cold water, to the surface of the body. A gentleman, who had bled to a very alarming degree, from the lungs, so as to endanger his life, unless speedy relief was afforded, was wrapt in a sheet, which han been dipped in cold vinegar, and the bleeding soon ceased.

2. The phenomena, which occur in the production of ague and fever, can be accounted for in no other manner. Every attentive practitioner, conversant with this disease, must have often witnessed the following facts which I have repeatedly seen, relative to that subject. Persons possessing sound health, and never subject to chronic diseases of any kind, on being exposed to cold and damp air so long as to be severely chilled, are often affected as follows. In consequence of the chill, or torpid state of the vessels on the surface of the body, induced by it, a universal paleness of the skin takes place. To this succeeds nausea, which is attended frequently with much acid and wind in the stomach; the heart and arteries cease to act with their wonted vigour; the pulse becomes small and feeble, and sometimes slower, but generally more frequent; universal languor and listlessness ensue, accompanied with frequent yawning. Pains in

the limbs, back, head and balls of the eyes follow, in many instances; the urine becomes pale and limpid, and is secreted in large quantities. Accompanying or succeeding these, we often find a severe ague. After some time the stomach, becoming more and more disordered, is at length relieved by vomiting. Soon an increased action takes place in the heart and arteries; heat in the skin follows; a copious sweat breaks out; and the patient is for a time free from his complaint. This fever sometimes consists of one paroxysm, and constitutes the ephemeral, or simplest kind of fever. If it returns after an interval of one, two, or three days, it constitutes intermitting fever. In either case, the symptoms are all a chain of sympathies. The primary disease is a disease of the skin merely. Hence it is so much more easily cured than other fevers.

Should morbid sympathies to a great extent similar, be occasioned by noxious miasmata, operating directly upon the stomach, by mixing with the saliva, the fever would become remitting, or typhus, perhaps of a malignant grade, would continue much longer, and be cured with much more difficulty. Here the *stomach* is primarily affected, and the disease is a disease of that viscus, or what I have ventured to call *a stomach fever*.

When the fever commences in the manner first specified, in a person having a disordered liver, several new sympathies take place. The disease is much more obstinate, and frequently cannot be cured, without particular attention to the disordered liver.

We come next to shew, that a peculiar sympathy exists between the stomach and other parts of the body. This may be evinced in two ways, viz. 1st. from the effects produced by morbid action, in the stomach, upon other parts of the body; and 2dly, by the effects of morbid action, in other parts of the body, upon the healthy stomach.

I. The Sympathetic actions produced by disease in the Stomach are very various, differing greatly in different persons, and in the same person, at different times. I will state a few only of such as I have often seen.

1. An Emetic taken into the stomach soon excites nausea. In consequence of the nausea a paleness of the

skin is induced, and a decreased energy in the action of the heart and arteries, the saliva, and the mucus from the bronchial vessels are secreted in much greater quantities than in health, or when the stomach is composed. As the stomach is excited into more violent action, vomiting is induced, and an increased action takes place in the heart and arteries. This produces a prickly sensation over the whole surface of the body, and usually an universal sweat ensues.

2. When the stomach of a person considerably debilitated becomes very empty, so as to excite severe hunger, a universal paleness spreads over the whole surface of the body. The pulse beats feebly and frequently, vertigo affects the head, the hands are in a continual tremor, and a great increase takes place in the secretion of the saliva.

3. Persons subject to tremors of the hands find temporary relief, from strong tinctures of the Peruvian Bark, or Colombo, or from a little good wine or brandy.

4. Syncope or fainting, occasioned by acrimony in the stomach, or by agitation of mind, or by inhaling an atmosphere vitiated by the respiration of a multitude of persons in a close room, may be usually relieved by a little brandy and water, taken into the stomach, or by dashing cold water on the face, or by volatile alkali held to the nose.

5. A small quantity of opium taken into the stomach occasions sleep, before there is a possibility of its mixing with the blood. An increased dose produces many symptoms of apoplexy.

6. A glass of very pungent small beer, or cyder, taken into the stomach after brisk exercise, in a hot day, occasions a prickly sensation throughout the surface of the whole body, in a few seconds, and often almost as soon excites an universal sweat.

7. When a person is much heated, and the circulation of the blood is greatly quickened by exercise, in a hot day, a large quantity of cold water taken into the stomach, will in many instances, suddenly induce severe spasm, and tetanus, and the most powerful stimulants, as laudanum and brandy, taken into the stomach, are the remedies most relied upon for relief.

8. Acidity and wind in the *prima via* of children produce convulsions.

9. Foul air being mixed with the saliva, and thus taken into the stomach, has produced a total cessation of all the animal functions, and apparent death.

II. The effects of morbid action, in other parts of the body, upon the healthy stomach, evince the existence of the sympathy contended for, as will appear from the following considerations.

1. Compression upon the brain, or a severe concussion of the head, usually produces nausea and vomiting.

2. Obstructed perspiration in the head sometimes occasions nausea, acidity, and wind in the stomach. I know a gentleman, who, whenever he puts pomatum and powder upon his head, experiences all these unpleasant symptoms, unless they are prevented by brisk exercise, and they continue till the pomatum and powder are combed out.*

3. Teething in children, which is wholly a local disease, often induces vomitings, acidity in the stomach, griping in the bowels, choler, cough, convulsions, and fever. Cutting the swollen gums alone, frequently gives great relief, and the cutting through of the teeth as usually perhaps, puts an entire stop to all the morbid symptoms.

4. Immediate vomiting may in many instances be excited, by tickling the throat and fauces with a feather.

5. Severe vomiting, owing to great irritability of the stomach, may be frequently relieved, when other means are ineffectual, by cloths dipped in laudanum, and applied to the Epigastric Region.

6. A blow upon the epigastric region, or pit of the stomach, will sometimes produce instantaneous death.

7. Dashing cold water upon the feet, will in some instances, procure an evacuation from the bowels, of a person obstinately costive. I know a gentleman who, whenever he wets his feet in the winter season, and suffers them to continue wet a sufficient length of time to produce slight chilliness, experiences a copious evacuation from the bowels. In several instances from walking a

* See Note A.

moderate distance in snow, partially melted, till his boots became thoroughly water soaked, much larger evacuations have been produced, than would have resulted from a heavy dose of calomel and jalap. It does not however usually occasion an equal degree of debility, with that which he customarily suffers from a cathartic; and almost immediately after the evacuation has ceased, his stomach and intestines will, by heating his feet, become tolerably composed. Another gentleman, whenever he undresses to bathe in river or sea water, experiences in consequence of the exposure of his naked body to the cool air, a free and almost immediate evacuation from his bowels.

A sympathy equally remarkable exists between the mind and stomach. This truth I will briefly illustrate.

1. Hard study or intense application of the mind produces wind, and acidity in the stomach, and costiveness, and general debility. Fools are observed to be proverbial for eating excessive quantities of food with sound digestion, while students are apt to suffer from loss of appetite and indigestion.

2. The indulgence of certain passions and emotions produce similar effects. A paroxysm of anger has occasioned, by its sedative effects on the stomach, sudden death.

3. Persons laboring under severe disease are sometimes completely and instantaneously cured by intelligence, which calls forth very sudden and strong emotions of the mind.*

Should the cause of this wonderful sympathy between the stomach and other parts of the body and the mind be asked, no hesitation can exist in attributing it to the distribution of the Par Vagum, or second branch of the eighth pair of nerves, and to its wonderful connexion with other nerves, particularly the *great sympathetic.* The Par Vagum, besides supplying the stomach, sends branches to the larynx, pharynx, trachea, oesophagus, vessels of the neck and heart, to the lungs, &c.; and by its connexion with the great sympathetic, a sympathy is established between the stomach and all the abdominal

* See Note B.

viscera, (viz. the liver, pancreas, spleen, intestines, kidneys, &c.) and the uterus, bladder, &c.

This sympathy was made by our Creator, for very wise and benevolent reasons. I will mention two only, which have presented themselves to my mind.

1. It appears to be a law of our nature, nearly absolute, *that the body is not liable to two general diseases* at the same time. If exceptions to this rule exist, they are rare, so far at least as my information extends. It also appears to be usually, perhaps almost uniformly the fact, that *one local disease*, or morbid action, arising in one part of the system, lessens or destroys a local disease or morbid action, which may have previously existed in another. I will briefly illustrate this subject. A person cannot at the same time, have the yellow fever and the measles. The operation of every blister in local inflammations or debilities, illustrates the latter assertion. Thus when from great irritability of the stomach obstinate vomitings take place, a blister upon the epigastric region, will afford great and often absolute relief. Hence when morbid sympathies arise from diseased action in the stomach, that viscus receives less permanent injury, than if no such sympathies existed. A transfer of a part of the morbid action is made from the stomach, to the sympathetic parts; and in some degree in proportion to the number or variety, and to the severity of the sympathetic actions, so that the stomach suffers only a part of the evil. Without this relief death would in many instances ensue, in consequence of the accumulation of morbid action in an organ so exceedingly tender and delicate.

2. We are thus warned of many things injurious to our health. In contemplating this subject we may, with the most evident propriety, say with the King of Israel, that "*we are fearfully and wonderfully made.*"

A physician accustomed to make accurate observations, might greatly benefit himself by noting, from time to time, such instances of sympathetic action as he met with in his practise.

The symptoms or morbid effects of Chronic Debility of the Stomach are,

1. Those which exist in the stomach and intestines. These are acidity; wind; a rancid state of the aliment-

ary matter; heat in the stomach; a gnawing sensation; a sensation of great emptiness; swelling of the stomach; an oppressive weight of that viscus after eating; distention of the intestines; depraved appetite; loss of appetite; unusual craving of food; spasms in the intestines; cholic; obstinate costiveness; or alternations of costiveness and diarrhea; or continued diarrhea, a great part of the food passing from the bowels unaltered; borborygmi; phlegm in the stomach; acid eructations; eructations of a thin, watery, and insipid fluid; frequent vomitings.

2. Those which exist in other parts of the body, and are owing to sympathy with the diseased stomach. These are vertigo, or swimming in the head; dimness of sight; pain in the balls of the eyes, with a continual tendency to inflammation; head ache; singing in the ears; a partial or total loss of voice; an early and rapid decay of the teeth; the constant formation of tartar upon the teeth; frequent teeth-ache; a sallow complexion; catarrh; cough; pulmonary consumption; pain in the back, attended with heat; wandering pains; tremor of the hands; pain in that part of the leg where the Gastrocnemius and Soleus muscles unite to form the Tendo Achillis, this is a dull pain, exactly resembling that which is induced by walking in tight boots in a hot day, till considerable fatigue is brought on; cramps; tetanus; small cutaneous pustular eruptions, especially about the wrists and thighs; hot flushes affecting the body generally, or a part of it; shiverings; syncope or fainting; palpitations of the heart; frequent yawnings and sighings; a pulse irregular, intermitting, quick, small and feeble; sometimes no visible perspiration from exercise, and sometimes copious and debilitating sweats; sudden weariness of the body or mind induced by ordinary exertions; liability to be greatly affected by changes of the weather, and to take cold easily; great irritability of body; great drowsiness, irregular sleep; sudden startings in sleep; laborious sleep, and sometimes constant watchfulness.

3. Those which affect the mind. These are great irritability; habitual discouragement, or what is often called low spirits; timidity; anxiety; irresolution;

fickleness; fretfulness; taciturnity; sadness; imperfect memory; strange whims; proneness to reverie; a fixed persuasion that the disease is incurable, and that it is of a totally different nature from what it really is; great impatience at being thought less sick than the patient had thought himself; frequent and strange dreams; night-mare; and sometimes settled melancholy.

These are all the symptoms which I recollect to have seen. That others may have occurred, I have no doubt; but I believe none of much importance have been omitted. It is by no means to be supposed that all of these ever occur in one case, for no two cases are exactly or even very nearly alike. A general similarity runs through the whole, and so many of the symptoms are present in every severe case, as to leave no doubt about the nature of the disease. On several of these it will be necessary to enlarge, with some particularity. Previously to doing this, I shall point out the differences between the disease under consideration, and certain others, having symptoms in some degree similar.

These diseases are,

1. A schirrous or other tumor of the stomach. Of this it may be observed, that it is very rare; that whenever it is so far advanced as to excite serious trouble, it occasions, according to accounts given of it, continual, severe, fixed pains; that the usual remedies for dyspepsia afford no relief; and that a tolerably correct opinion may be formed from the manner of its commencement and progress.

2. An arthritic humor in the blood. With respect to the existence of such a humor, although much has been written by ingenious men on the subject, not a shadow of proof has been exhibited, so far as my knowledge extends. When it shall be exhibited it will be time enough to consider it; till then it may be fairly ranked with other ingenious whims, which have served to amuse their authors and mislead mankind. That there is in some instances what is usually termed *a retrocedent gout*, there can be no question; or, in other words, there is a translation of the morbid action; or, in other words still, the several morbid actions which constitute a regular case of

gout, sometimes suddenly leave the feet chiefly or wholly, and several distressing and occasionally alarming symptoms as suddenly appear in the stomach. A similar translation of morbid excitement takes place in many other diseases. I knew a patient wasting rapidly with the pulmonary consumption, who, at a certain time during the progress of this complaint was seized with mania. Immediately on the commencement of the latter complaint, the hectic fever, the night sweats, the expectoration, the cough, and in short every symptom of the former one vanished. After the lapse of several days his mind became rational and composed, and then, and not till then, his former disease returned, and with redoubled violence. We might therefore, with the same propriety, talk of a maniacal humor, a pulmonic consumptive humor, or any other humor that happens to please our imagination.

3. The hysteric disease. With respect to this subject I can say nothing which has not been said by others, and shall only observe, that there is usually no difficulty in determining the nature of the complaint; and that many of its most distressing symptoms are connected with, or occasioned by debility of the stomach.

4. There is a morbid irritability of stomach sometimes met with, which is constitutional and peculiar; in consequence of which great distress is occasioned by certain kinds of food, which to most persons not only produce no inconvenience, but prove mild and nutritive. Thus, some persons are unable to eat strawberries, others cheese, and others other kinds of food, without great inconvenience. Certain anomalous symptoms usually attending such cases, the previous state of health, and the physician's own sagacity, will ordinarily leave no doubt as to the nature of the evil.

Having endeavored to clear the way of all obstructions, I shall next consider, some of THE EFFECTS of Chronic Debility of the Stomach. I mentioned them all briefly together, that they might be seen at one view.

I. THE PRODUCTION OF ACIDITY IN THE STOMACH. This is the first and most distressing effect, and the parent of many others. As I have no where seen any discussion of this subject, ; as it appears to me to be of no small importance; and, as the ideas, which I shall advance relative to its nature and effects, may not be readily admitted by others; I shall examine it with some minuteness. It appears to be the general opinion of physicians, so far as my informaion extends, that the acid found in the *Primæ Viæ*, is derived from a fermentation of the alimentary matter. That such an opinion should have universally prevailed, is not to be wondered at. It is not long since the medical world attributed the process of digestion chiefly or solely to this cause. That the acid, which is sometimes found in *healthy stomachs*, is produced in this way, I have no doubt; and that the acid found in debilitated stomachs is, in many instances, owing to the same cause, I also admit ; especially where the disease consists of what may be termed a paroxysm, that is, an attack which lasts from one to four days, commencing suddenly, and leaving the stomach free from the evil, by means of a spontaneous diarrhea, or some other cause. Such paroxysms I have often known. The disorder in this case is brought on usually by eating acid fruits, or beans, or peas, or other vegetables, which are tough and old, or pastry, or by drinking wine or porter in a slight degree sour, or by eating to excess food generally healthful. The acid in this case evidently proceeds from fermentation, and the great quantity of gas or wind extricated, together with other circumstances unnecessary to be mentioned, prove it. But there is an acid state of the stomach differing widely from all this, often continuing many weeks, and months, and sometimes years, without material abatement, and this in spite of all regulations of diet ; often lessening the appetite greatly during its continuance, producing obstinate costiveness, and excessive torpor of the stomach and intestines, without ordinarily occasioning wind in those viscera, at least to a greater degree than is usual to those who enjoy sound digestion ; producing also headache of many months continuance, or daily periodical headache and universal debility, and sometimes, perhaps usually, connected with an acid state of the saliva. This also admits of aggravations or paroxysms, induced by various causes. The acidity in such cases I suppose to be owing to a *morbid secretion of the gastric liquor.* I began to be of this opinion in the month of August 1803, or rather I was led at that time to attribute it either to this cause or to a *decomposition of that fluid*, after it was secreted. At the period specified, the stomachs of some persons at Catskill, who had the yellow fever, generated such enormous quantities of a most corrosive acid, without having taken such food as would be likely to produce it, and almost without any food at all, that it seemed to me inexplicable in any other manner. Cullen has suggested the possibility of such a derivation, in some cases, but considers imbecility of the muscular fibres, as *almost the sole cause.** Some of the arguments, which have led to this conclusion in my own mind, I will proceed to state.

1. The existence of a very sharp corrosive acid, without being accompanied by gas or wind. Probably every person severely affected with permanent debility of the stomach, may have experienced something of this nature. I have often experienced it, and in some instances for three months, without any intermission, and should probably continue to experience it, till it ended in the destruction of life, did I not throw it off, by brisk and long continued exercise. During its continuance, I am every day affected with a greater or less degree of headache, and constantly lose flesh and strength, while it is still unattended with wind in the stomach and intestines, or with a greater quantity than is usual to persons in good health. Neither is it accompanied by what is commonly termed a foul stomach. The stomach becomes exceedingly torpid, and requires a very large dose of some powerful emetic to excite vomiting, and when it is induced, nothing is brought up but *an acid mucus*, unless, by violent straining, bile should be forced from the duodenum into the stomach. The acid is often extremely corrosive, so as in some instances, to excoriate the fauces. The vomiting however is of no service. It greatly weakens the stomach for a time, and in twenty-four hours the acid is as abundant as ever. Now if it was produced by a fer-

* See Note C.

mentation of the alimentary matter in the stomach, there would be a constant extrication of gas, and this would bear some proportion to the quantity of acid. I have also almost uniformly found, that where the disease consisted of a paroxysm, produced by acid fruits, or other food, occasioning a rapid fermentation of the alimentary mass, vomiting was easily excited, and gave complete relief; and, in the course of twelve or twenty-four hours, the stomach became composed; or a spontaneous diarrhea came on, and produced a similar effect.

The acid, at times, without the aid of any fermenting mass in the stomach, comes on with great violence, and in spite of all efforts short of brisk and repeated riding on horseback, or much hard labor, lays prostrate the whole energy of the system. In spite of my utmost endeavours to overcome it, I am sometimes compelled to give way to it for short periods, and even to betake myself to my bed. When the paroxysm is less severe, it is often the case that one half of the strength of the muscular and nervous systems is destroyed, during its continuance. At such times I am able to walk but short distances, without great weariness, languor, faintness, and sometimes manifest disadvantage; and any degree of walking which I can then accomplish, will not occasion sweating.

The following brief recital may further illustrate this subject. In the month of July of the last year, during some very hot weather, I imprudently laid aside the use of a flannel shirt. No immediate ill effects apparently resulted from the want of it; but in six or eight days my stomach became highly acid, and at the end of the first fortnight I was seized with a severe attack of cholic. The acidity was now become intense, and the saliva disagreeably sour. No flatulence accompanied or preceded the paroxysm. By putting on a thick flannel shirt, which excited much irritation on the skin for a short time, I speedily obtained relief.

2. The effects of severe study, or application of the mind, upon the debilitated stomach. This uniformly produces a great influx of acid into that viscus, an acid of a very corrosive nature, and producing by sympathy, great debility throughout the system. So great effects

cannot be owing, it appears to me, to fermentation. The cause assigned does not appear adequate to the production of evils, so suddenly induced, and attended with such distressing consequences.

3. Strong passions of the mind often produce an influx and accumulation of acid in the stomach, in a very short time; much sooner than we are authorized from acknowledged facts, to attribute to fermentation. A person, who has not been attentive to this subject, would be greatly surprized to witness the effects, which sometimes result from this cause. Any unusual agitation of mind produces a similar effect. A lady, who suffered a sudden and violent fright, perceived an immediate and copious influx of acid into her stomach. She was previously free from this evil.

4. This opinion derives no small support from the effects which are in some instances produced on the stomach, by a blow on the head, or a concussion of the brain, or a general concussion of the body, occasioned by falling from a height. One of the effects of such violence done to the system is, often, the sudden production of nausea and vomiting. The matter ejected by vomiting is frequent- acid to a high degree, and this too in stomachs, where acid before was rarely or not at all experienced, in persons of very robust habits, persons accustomed to eat all sorts of food with impunity, hard labouring men, such as would ridicule the idea of acidity or debility of the stomach as applied to themselves. How shall this be accounted for? In my own opinion, only in the following manner: The stomach becomes either primarily, or sympathetically, or in both ways, immediately disordered, and to such a degree as to occasion great alterations in the secretion of its fluids, both in their nature and quantity. Every one who has been conversant with subjects of this nature, must have noticed that, in cases where the violence done to the system is considerable, the pulse immediately ceases to beat, and a universal torpor and coldness, like the coldness of death, comes on as suddenly, over the whole surface of the body. This state of things greatly increases the disorder of the stomach, and the acid flows forth from all its secreting vessels. The

acidity of the stomach, in slight cases of this sort, is not evident to a cursory observer in some instances until a considerable period has elapsed; in others acid is vomited up, in large quantities, in fifteen minutes, in others in ten minutes, in others in five, and even sooner. Does a morbid secretion begin and advance to this extent so speedily? I have no hesitation in asserting my belief that it does. In severe cases, and in debilitated stomachs, it commences perhaps immediately after the injury is done. I well remember that in two instances, where I suddenly fainted away from extreme pain occasioned by violence done to a particular part of the body; I found on reviving, great coldness on the surface of the body, and much acid in the stomach, where before there was little appearance of that evil. The paroxysm, in either case, did not exceed four or five minutes. Is it not reasonable to conclude that, the secreting vessels commence a wrong action at their mouths, as soon as they are disordered, from the concussion, or from the derangement of the brain, or from the torpor and chilliness of the cutaneous vessels; and that this wrong action is propagated throughout the secreting vessels almost instantaneously.

The following case may serve as an illustration of the foregoing assertions: About a year ago, one evening on my return from a journey to New-York in the stage, a lady, who had appeared through the day to be in perfect health, was suddenly rendered unwell in the following manner: In consequence of the destruction of several bridges, and other injury done to the turnpike road by repeated and copious rains, it was necessary in a certain part of the route to pass over several miles of an uneven and stony bye-road. In a particular part of this road lay a small bridge, the descent from which was between one and two feet. We passed over this bridge rapidly. The fall of the carriage was sudden and violent. The passengers were all much jolted, and the lady abovementioned immediately fainted. On her account we rode the remainder of the distance slowly to the stage house. It was between twenty and thirty minutes before we arrived. During the whole of this period she continued totally bereft of sensation and voluntary motion. It became necessary for me to support her in my arms. I perceived within five minutes that her stomach was considerably acid. Immediately on stopping, by the aid of brandy applied to her nose and face, she vomited freely and became speedily well. Her skin throughout was cold like that of a dead person, and no warmth was restored till the vomiting took place. From various circumstances, I am satisfied that her stomach was entirely composed previous to the occurrence, and that the acid was formed afterwards, and in consequence of the shock abovementioned.

5. Sudden changes of the weather, or standing in the open air with wet feet, in cold and damp weather, till a general and considerable chilliness is experienced, has a similar effect, on the stomachs of many dyspeptics. In proof of this assertion, I would alledge the following case.

A gentleman who had been for ten years troubled at intervals, with severe debility of the stomach, and much acid in that viscus, being in good health, one day in the month of April last, instead of wearing his boots as he had uniformly done for six months preceding, wore shoes. Though he was out of doors but a short time, yet he experienced in two or three hours chilliness, and acid in the stomach. A severe headache ensued, and though he put on his boots very soon after the commencement of his ill feelings, and kept on an abundance of clothing, yet they rapidly increased; so that he found it necessary to go to bed in the beginning of the evening. Within fifteen minutes he had several smart agues. These were succeeded by very severe cholic, and extreme acidity in the stomach, and in a little time violent vomiting was induced.

There was very little appearance of wind in the stomach or intestines, nor any bile vomited up. During the vomiting, a copious sweat broke out, which by the addition of bed clothes, was kept up through the night. The next morning the patient was nearly as well as usual. After an attentive examination of this case, I could not hesitate to attribute the head ache, the agues, and the cholic, to the acidity of the stomach, and this to a morbid secretion, brought on from sympathy between the secreting vessels, and the feet, rendered torpid by unusual exposure to cold. I have often experienced similar effects, from similar causes, but much more suddenly following them.

6. This opinion is rendered probable from the state of the saliva, in some dyspeptics. In those severe cases of the disease where the stomach is affected with mere acid, the saliva is acid also. This fact I have experienced many hundred times, and for months together, without any mitigation. The kind, and degree of sourness, it is difficult for me to describe definitely. If the acid in the stomach is occasioned by fermentation, how shall this phenomenon be explained? In those paroxysms of acidity, unquestionably occasioned by a fermentation of the alimentary mass, I have not known an acid state of the saliva. But if we admit that there may be a morbid secretion, or a decomposition of the gastric liquor, the difficulty will be removed, since the former fluid is employed in preparing the aliment for the action of the latter, since it possesses corrosive and antiseptic properties, and has a far greater affinity to the gastric liquor than any other animal fluid, except the pancreatic.

7. The following case affords additional evidence in favour of the opinions which I have endeavoured to support.

In the summer of 1804, I was called to visit Mrs.—, a lady aged about 30, of an exceedingly delicate and irritable habit. She inherited a feeble constitution, had been married very early, and went through her first labour when she was a little more than sixteen years old. She was shortly after attacked with puerperal fever. From this disease she with difficulty escaped, and continued in a low state, a long period of time. When I saw her she was the subject of great general debility, and of singular weakness of the stomach. She was also greatly distressed by a continual and copious influx of acid, into that viscus. The paroxysm had been on about twenty-four hours. During that period, and for some time previous, she had taken no sustenance, and was unable to retain any thing upon her stomach, but was afflicted with very frequent and painful vomitings. She brought up nothing, however, but thin mucus, and this was discharged in great quantities, and of a very deep green colour. The colour was of about the same intenseness, as the leaves of the hemlock tree, and was owing as I suppose, wholly to acidity. The mucus was so extremely acid as to excite great distress, whether it remained in the stomach, or passed the fauces by vomiting. It occasioned, repeatedly, severe spasms, and could not be materially checked, by such measures as were made use of, under twenty-four hours more. About that time the disorder ceased, the irritated organ became composed, and she soon regained her usual health. This paroxysm was occasioned as I suppose, by the debilitating effects of extremely hot weather, and some irregularities of diet and exercise, operating upon a system universally predisposed to disorder, and upon a stomach intensely irritable, always prepared to engender acid, and to sympathize with every morbid affection of the body or mind. Could the phenomena here recited, have been occasioned by a fermentation of the alimentary matter? Should the answer be given in the affirmative, I would ask what there was in her stomach, to undergo the process, besides mucus, and the gastric liquor? Should I in my turn be asked, how such an enormous secretion, of so depraved a fluid, can take place from the vessels of the stomach, I answer, that from some cause or other, which man perhaps cannot explain, a determination of the fluids of the body is induced towards, or in, its secreting vessels, so that in the case specified, the quantity secreted was ten, perhaps twenty times as great, as in an equal space of time, in health; and the secreting vessels, in consequence of being surcharged with fluids, were thrown suddenly into a state of violent morbid excitement.

Phenomena in many respects similar to this, occur daily, in the production of diarrhea, and dysentery. I will illustrate my meaning, by a brief recital of the following case. A gentleman some years ago, having occasion to perform a short journey, left home in the evening, and rode a considerable distance in an open carriage. The day had been very hot, and being in high health, he had not provided that additional clothing which is usually necessary, on such occasions, even in a hot night. After riding several hours, he became severely chilled. He continued his journey till some time after midnight, and when he stopped went immediately to bed, without taking food, or even warming himself. He had not been long in bed before he was forced to rise, from severe pain in the bowels, and in a few minutes he discharged more than four quarts of fluid fœcal matter, chiefly mucus. This was doubtless owing to the torpor, induced on the whole surface of the body, by means of the chill, and the consequent retreat of the mass of fluids towards the intestines. Is not the latter event in all respects, except its frequency, as extraordinary as the former? Let it be further remembered, that the fœcal matter which is discharged in many cases of diarrhea, and dysentery, induced in a manner similar to that in the case specified, is highly acrid, so as often to excoriate the intestines; may I not say so as in some instances to occasion death? Whence does this acrimony arise?—Surely not from a fermentation of the alimentary matter? The next subject of enquiry is, whether the acid *in question*, may not be occasioned by a decomposition of the gastric liquor? For a considerable period I remained at a loss to determine, whether we must look to this cause, for the source of the evil, or to a morbid secretion of that liquor. Having not long ago investigated the subject more minutely, I have become satisfied, that it is owing to the latter cause; and in no instance to the former, *where the fluid is secreted in a healthy state*, that is, *possessed of its usual properties, and no other*. In all other cases the acid is occasioned by a fermentation of the alimentary matter. The reasons which have led to this conclusion, I will proceed to state.

1. In several cases which have been stated, and in others which might be, there appears to be no cause adequate to the production of a decomposition of the gastric liquor; if we admit that that fluid *was secreted* in a healthy state. There is no unnatural heat in the stomach, nor any known chemical agent, introduced by the mouth. The effect, also, is often too sudden, and too considera-

ble, to be produced by decomposition, without the aid of chemical agents.

2. The nature of the gastric liquor is such, as to render it highly improbable, that it should undergo such a change, unless it was first secreted in a morbid state.—Though I have not been able to obtain any chemical analysis of it, on which much reliance can be placed, I can state the following interesting fact, which proves what is generally admitted, but by some respectable writers denied, that this fluid possesses singular antiseptic powers. Some years ago, Æneas Monson, M. D. late President of the Medical Society of Connecticut, obtained about a quart of gastric liquor, from the stomach of an ox. The animal, previous to its being killed, had been fasting an unusual length of time. Notwithstanding this advantage, the butcher who collected it, did not obtain it so pure and free from admixture with other substances, as was expected. In consequence of this fact it was put into a junk bottle, tightly corked, and placed by a servant in the cellar, on the top of the wall, by the window, with an intention of letting it stand a few days, to settle. When it was called for, the servant was unable to find it. It remained in this situation between one and two years, before it was discovered. On opening it, it was found to be perfectly sweet, and to smell very exactly like the breath of a healthy cow. This occurred during the hottest weather of the summer. The liquor was carefully poured off into another bottle, which was well corked, and set aside in a proper place, where it remained a year longer. It was then opened, and the liquor had apparently undergone no changes, but was perfectly sweet.—Now when it is remembered that this liquor was obtained, not from the stomach of an omnivorous animal, as man, but from that of a herbivorous one, and that the gastric liquor of the former, as is admitted by various physiologists, is less disposed to ferment, than that of the latter; that it remained for such a length of time, exposed to great alterations of heat and cold, and to the influence of light; it may with the utmost propriety be asked, *is it credible that a liquor possessing such properties, should*

undergo decomposition, in the stomach, in two or three hours?

3. The argument derived from analogy lends its whole force, to support the same conclusion. Many of the other fluids of the body are, at times, in a morbid state. This is true of the wax in the ear, the milk, the urine, the pus of ulcers, the sweat, and the saliva: might I not say of the bile also? I have in another place mentioned the existence of acid saliva. I know a gentleman, who, some years ago, suffered much from general debility, and very uncommon weakness of the stomach and intestines. During the hot weather, light exercise would throw him into a profuse sweat, so that numerous drops would stand upon his forehead. This was, as I often observed, of a very strongly acid smell, immediately after it appeared, or, in other words, before it could have undergone any decomposition. Should it be supposed, however, that it was owing to decomposition, I would enquire why we do not find the sweat of healthy men, becoming acid in the same manner? The milk of the female undergoes changes more remarkable, and in very frequent instances. It is well known that the milk of the cow is often disagreeably flavoured, with the food she eats, or by violent exercise. It is equally well known that infants at the breast, are often disordered, by irregularities in the diet of the mother, or nurse. Acid, gripings, and wind in the stomach and intestines, cramps and convulsions, and even death itself are sometimes the consequence. The milk is asserted, by respectable authority, to have been salt and bilious. Experiments have been made which prove, that it is sometimes essentially altered, in its properties, by a change of diet. Thus it appears that certain animals, confined wholly to a vegetable diet, secrete a milk acescent, and easily coagulating, which when fed wholly on animal food, secrete a milk alkalescent, and not spontaneously coagulating. There is also, in some instances, a deficiency in the quantity secreted, and in others, a redundancy. The bile sometimes undergoes changes, from sudden and violent passions of the mind, and from other causes. The urine differs wonderfully, in different persons, and in the same person at different times, when in

health, and much more in disease. I have seen urine of a deep green colour. The secretion of the mucus matter from the schneiderian membrane, is greatly altered, by what is usually termed *a cold in the head.* Whenever I take cold, the whole force of the disorder is, in most instances, spent upon the stomach and intestines. Why should not the gastric liquor be affected by it? Nothing perhaps will serve better to illustrate this subject, than the changes, which frequently take place, in the matter discharged from ulcers. The simple purulent ulcer is a disease, it is well known, entirely local, yet it is capable of undergoing great changes, from affections of the system. In healthy persons the matter secreted on its surface, is a mild bland liquor, called by surgeons *laudible pus.* In persons greatly debilitated and highly irritable, it not unfrequently possesses considerable acrimony and fœtor. A healthy patient, who has undergone an amputation of a limb, will usually, when the wound becomes an ulcer, or when the secretion of matter takes place on its surface, experience considerable mitigation of pain; the discharge will, with proper treatment, be a *laudible pus*, and the patient will speedily recover: but if, when the inflammation in the wound subsides, and the *pus* is secreted, the patient, instead of being kept on nourishing diet, should be confined to that of a contrary nature, and should receive few or no stimulant or tonic medicines, the matter secreted would soon change its colour, become thin, acrid, and fœtid, and excite great irritation in the patient; but if, in this situation, he is furnished with a due quantity of bark and porter, or good wine, and nourishing diet, all the unpleasant symptoms will in twenty-four hours, be greatly mitigated, and if this course is pursued a little time, be wholly removed. I suppose no one will contend that, in such a case, the *pus* is decomposed. It will probably be admitted by all, that it is secreted in a morbid state. Is there not a morbid secretion in every phagedenic ulcer? Who ever heard of ear wax decomposed in the ear, or milk in the breast of a female? Especially can it be supposed that these things will take place, if the several fluids are secreted in a healthy state? One fact further relative to this subject, and I have done.

A gentleman having suffered the sebaceous matter which is secreted under the prepuce, to remain till it had acquired some acrimony, was affected as follows. A very great increase took place in the secretion, even to more than twenty times the usual quantity, and instead of its ordinary mildness and consistency, it became highly acrid, thin and of a pale colour. In spite of the utmost attention, it continued many weeks, and was with great difficulty removed, by the aid of very powerful stimulants. Now I would ask, is there any greater difficulty in admitting a morbid secretion of the gastric liquor, than there is in admitting the existence of the facts abovementioned? It may be remarked further, that when secreting vessels have taken on wrong action, it is, in many instances, difficult to restore them, and that when relieved, they are apt from very slight causes, to be disordered again. I have dwelt the longer on this subject, because all the physicians with whom I have conversed, excepting one or two, have been wholly unwilling to admit, even if the gastric liquor were supposed to undergo any changes, that it could *be secreted in a morbid state ;* but have supposed that such changes must be owing to decomposition. If it is secreted in a morbid state, I cannot say that it does, or does not undergo further changes in the stomach. I have no facts in my possession, which will warrant me to form a decisive opinion on this subject.

What the nature of this acid is, I do not know. Dr. Eli Ives, of this city, supposes it to be the phosphoric ; from its strong resemblance to that in taste. No chemical analysis of it has been made, within my knowledge. Phosphoric acid has been discovered in the gastric juice of the sheep, the calf, and the bullock, and from these circumstances it is not impossible, that the conjecture is right.

The effects which the acidity in question produces, are, many of those which have been already mentioned, as symptoms of Chronic Debility of the Stomach. I say that these are produced by acidity, because I have often experienced many of them in my own case, and seen them in other cases, taking place immediately on the commencement of a paroxysm of acidity, and subsiding, and ceasing, as that paroxysm abated, and went out. These are a gnawing sensation in the stomach, a sensation of emptiness, severe hunger shortly after eating, irregular appetite, unusual craving of food, cholic, spasms of the intestines, tetanus, costiveness, diarrhea, acid eructations, vertigo, headache, decay of teeth, tremor of the hands, pains in the legs, cutaneous eruptions, cough, catarrh, pulmonary consumptions, and low spirits, and all the other morbid affections of the mind. All symptoms are greatly aggravated by an acid state of the stomach. All the above morbid effects in dyspeptic persons are occasioned by acidity exclusively, except cholic, spasms of the intestines, tetanus, costiveness, diarrhea, vertigo, headache, cutaneous eruptions, cough, catarrh, and pulmonary consumptions. I know not that cholic in adults is usually attributed to acidity, but have met with several marked cases of it. The only case of tetanus occasioned by it which I have seen, or heard of, is the following. Mrs. —, the lady before mentioned, who was so remarkably troubled with acidity in the stomach, being extremely afflicted with her old complaint, and her mind being irritable and fickle, was carried out one morning in the month of March, some years ago, about four miles from home, to spend the day at the house of a friend. Some hours before evening she became anxious about her children, and in spite of all remonstrances, she refused to wait for her carriage, and returned on foot. The weather was raw and damp, and she was dressed with the clothes of summer. Early in the evening she complained of being unwell, but as she was frequently indisposed, no particular attention was paid to her, till about midnight, when I was sent for. Her husband was absent, and there was no member of the family present who was qualified to direct, or to judge discreetly about her case. Some neighbours had been called in, and from them I learned what has been already related, and became satisfied that her complaints were owing to excessive disorder of the stomach, induced by unusual fatigue and chilliness. She was affected with tetanus to a very severe degree, so that her head, neck, limbs, and every part of her body were perfectly rigid. A case apparently more threatening, I believe to be rarely met with. Though her eyes were open, she appeared wholly insensible, and her pulse was threadlike, fluttering, and apparently on the point of retiring finally. I had not long to deliberate. She had lost several teeth. I attempted to pour something through the passage down her throat, but the muscles of the fauces and cheeks, and the tongue, partook of the disease to such a degree, that every attempt was fruitless. The liquid immediately ran out at the sides of her mouth, and not a drop was swallowed. It occurred to me that I might possibly attain my object, by pouring a drop or two of volatile spirits of ammonia into one of her nostrils. Having a small quantity of it near at hand, which was highly pungent, I went for it, and after I returned, in attempting to accomplish my object, some of the bystanders being curious to see what I was about, hit my elbow. In consequence of this, about a teaspoonful was forced into her nose, and as her head was at this time bent greatly backward by spasm, it all reached her throat. In a moment her whole body became relaxed; she was seized with the most violent coughing which I ever witnessed; but soon recovered so far as to speak, and appeared to be greatly distressed. The coughing was so extremely severe, and continued so long without abatement, and the appearances of strangulation were so threatening, that the bystanders were terrified, and I was at a loss for a few minutes concerning the consequences. In a little time, however, she became so far composed, that she was able to swallow sixty drops of laudanum. In ten minutes from this time, her tetanus returned with as much violence as before. I resorted to the same measures to restore her, as in the former instance, except that a few drops only of the spirits of ammonia were administered. This had the desired effect, without producing a very distressing cough. As that subsided, I gave her sixty drops of laudanum the second time. As often as she appeared relapsing into her former state, the volatile alkali was used, and before two o'clock in the morning, I had given her three hundred drops of laudanum. As she then appeared in a great measure composed, I desisted. The ensuing day she was pretty well. Acidity in the stomach alone, would not, I suppose, have produced so great an effect, without the aid of other causes. The other causes, surely, would not have produced them, without the acidity. The acidity was the *causa sine qua non.*

II. Wind in the Stomach and Intestines.—This evil is produced by a fermentation of the alimentary matter. In healthy stomachs such a fermentation usually exists, in a very small degree only ; but on some occasions from over-eating, or from a very free use of acid fruits, or from fatigue, or from such an exposure to cold and wet as to induce torpor in the extremities, or over the surface of the body generally, aided by the other causes, it is excited in a considerable degree even in them, for a short time ; but in such instances the excess of acid which ever accompanies it, usually occasions a free diarrhea, and the patient in a few days enjoys his customary state of health. In dyspeptics, on the contrary, the fermentation is occasioned by a very slow and imperfect digestion, which is owing to the morbid state of the gastric liquor, and to the debility of the muscular coat of the stomach. This debility of the muscular coat will occasion on the one hand, a relaxation of the plaits or folds about the pylorus; and thus a protrusion of some parts of the alimentary matter into the intestines will take place, before it has undergone any considerable change; and on the other hand, the muscular contractions will be so feeble as not to force all the alimentary matter through, in due time. The heat and morbid juices of the stomach, and the liquids which were taken in with the food, will occasion it in many instances, to undergo a very rapid fermentation. The quantity of wind extricated will sometimes be enormously great. I knew a person, who, from eating moderately of various kinds of food which to healthy people are always mild and inoffensive, was on some occasions afflicted with this evil to such a degree, that eructations of wind were induced, which continued for two hours, with scarce a moment's intermission.

The morbid effects which wind produces, are, distension and spasms in the intestines, borborygmi, cholic, eructations, vertigo, wandering pains, palpitations of the heart, yawnings, sighings, irregular sleep, drowsiness, strange and frequent dreams, whims, low spirits, and many indescribable sensations, as some persons term them. It also aggravates most of the other symptoms of the primary disease. That these are the genuine effects of wind in the alimentary canal, is evident from the fact, that when it is expelled by carminatives, they frequently cease. They come on as the wind is produced, and disappear as that disappears. Women are much more afflicted with this evil than men. The causes of this fact are, a too sedentary life; thin dress in cold weather, in consequence of which the body becomes chilled; thin shoes, by which the feet often become very cold and wet; and lastly, eating too freely many improper sorts of food.

III. Rancidity in the Stomach. This complaint is occasioned by a too free use of oily food, such as gravy, melted butter, fat meats, particularly such as are smoaked, rich pastry, and by old and dried beans and peas.—That the oily food which I have specified is prone to become rancid in the debilitated stomach is evident from the following considerations. Butter imperfectly freed from the buttermilk becomes, in warm weather, from no other causes than exposure to heat and the surrounding air, speedily rancid. How much more ought it to be expected, that such an admixture of oils with fermented and unfermented acids, with pastry imperfectly baked, with hot drinks, distilled spirits, and all that mass of vegetable and animal matter, which make up the diet of many persons, should, when aided by the heat of the stomach, and the fermentation going on there, produce this effect! Animal oils are probably used to a greater extent, as food, in this country, than in most others. In travelling several thousand miles, in the states of New-England, New-York, New-Jersey, and Pennsylvania, I have every where met with great excesses of this sort. As the people of the United States are, to a great extent, from the manner in which it has been settled, and from their enterprizing character, accustomed to travel, it may be fairly concluded, that such food is served up at the inns, as is generally agreeable. Here we often find fat meats, brought on to the table, swimming in gravy or melted butter; a very general use of toasted bread, soaked and resoaked in the latter article. In many parts of the country westward and southward of New-England, the meats of all sorts are, to a great extent, fried in fat; and in the northern parts of New-England far more gravy, and melted butter, and fat meats are used than are healthful, except for very robust and hard labouring people. This state of the stomach, connected with Chronic Debility of that viscus, is the most distressing that I have ever seen. All the evils resulting from acidity, are here to be looked for, in their worst forms. Obstinate habitual headaches are frequently, and wholly removed, merely by the disuse of gravies and fat meats.

IV. COSTIVENESS. This is a very common, and most troublesome effect, of the disease under consideration. It is usually greatly aggravatad by acidity, and in its turn not a little increases that complaint. It is induced in part also, by weak muscular action of the stomach and intestines, and by deficiency in the quantity and quality of the bile. It often exists for a great length of time, and to a very distressing degree. No person can continue to feel well, who is habitually costive.

V. DIARRHEA. This complaint, in dyspeptic persons, is of two kinds, that which consists of short paroxysms, succeeded by long intervals of costiveness; and that which is habitual, continuing many months, and sometimes years. The first is owing to an extremely irritable state of the stomach and intestines, thrown into violent and irregular excitement, by acid fruits, and pastry, and various other indigestible species of food: the second to an excessive torpidity of the same viscera, in consequence of which the food passes through the intestines, nearly in the same state, in which it was received into the stomach. This complaint is often extremely debilitating, and troublesome.*

VI. PAIN AND WEAKNESS OF THE EYES. These are sometimes extremely troublesome, and not uncommon effects of the same disease. When they are produced by this cause it may be usually known, from the time

* See Note D.

and manner of their commencement, from their increase or abatement, as the acid, wind and costiveness are lessened, or increased. These complaints, when they are not at first brought on by debility of the stomach, but have existed previously to that disease, are greatly aggravated by it; and it is in many instances very difficult, perhaps impossible, to cure them, till a material change is produced in the state of the stomach. Similar remarks might with propriety be made, respecting the long continued and periodical headaches of dyspeptic persons.

VII. Catarrh. This complaint has had, in almost all cases to which I have been particularly attentive, a much more intimate connection with the state of the stomach, than is generally supposed; and is often extremely troublesome. It sometimes exists to such a degree, that no small difficulty is experienced in reading aloud, in singing, and even in conversing, and it excites in some instances a *hacking cough*, as it is colloquially and not unaptly termed, which is almost incessant. Catarrh is often greatly aggravated, in persons having debilitated stomachs, by living near the sea shore, and by breathing a mixture of sea and land air; yet that ought not to be considered as its chief cause. Though such persons usually experience great relief in this complaint, by a voyage to sea, or by residing at a distance of one hundred miles or more from the shore, where the air is neither so variable nor so stimulating to the lungs; and though, on approaching the shore, the complaint returns with increased strength; yet, when their digestion is vigorous, they perhaps as often experience little or no inconvenience from such a residence.

In the year 1800 I began to be afflicted with this complaint, to a very uncomfortable degree. About the same time my stomach had become the seat of distressing debility. The catarrh lasted without material abatement, three years and a half. I then went to reside at Catskill. In a little time after, it almost wholly left me. I attributed the relief to the free use of snuff. After some months had elapsed, I returned to New-Haven on a visit, and during four days which I spent here, experienced more of the complaint, than I had done during the preceding two months. After some time I ceased from taking snuff: the catarrh did not return, but in several instances on my visiting the shore I had short and severe paroxysms of it, which ceased immediately on my going back. Since my return finally to this place in the year 1805, to the present time, I have suffered but little from this source except in moist, cloudy weather, and during a paroxysm of acidity in the stomach, when the catarrh is nearly as severe as ever. If at such a time, I ride in an easy chaise, directly along the sea shore, for two or three hours, with the wind blowing from the ocean on to the land, it induces such a degree of horrseness, that I cannot speak a loud word. Brisk exercise, or a better atmosphere, will soon give relief. When in good health, I experience these evils, under similar circumstances, only in a small degree.

VIII. Cough, Loss of Voice, &c. There is a cough attending this disease, aside from catarrh, and very properly termed by people in general, *stomach cough;* often rendered considerably troublesome by the prevalence of acidity, with no expectoration, or a very small and difficult one. The same cause also, sometimes occasions a partial or total loss of voice. Hundreds of times I have known the voice, so far weakened by a paroxysm of acidity in the stomach, as to render it inconvenient and painful, for one or more days at a time, to read loud half an hour. And I have met with one or two cases, where persons were unable to speak out of a whisper, for a long period of time, which I attributed to sympathy with a debilitated stomach, and which I could account for, in no other manner.

IX. Consumption. This disease, when occasioned by the cause now alledged, is chiefly confined to delicate young ladies, between fourteen and twenty-one years of age. There is usually in such cases, an hereditary debility. To this, great accessions are made, by the most delicate and ridiculous nursing in childhood; by the avoidance of exercise afterwards; by a diet of slops; by confinement at home; by fashionable dress, cramping and compressing some parts of the body, and leaving others naked; and a universal round of absurd management. Such a course of life will assuredly induce universal debility, a sickly appetite, and extreme weakness of the stomach and intestines. Consequent upon this, comes on daily vomiting after every meal; a series of morbid sympathies take place between the stomach and uterus; and unless vigorous measures are now taken, a quick consumption will, in many instances, speedily ensue. The colourless, half formed, inanimate being will, like a tender plant reared in a hot-house, at the sting of the first insect, wither and die.

X. Pain in the Lumbar Region. Of this I have known but one instance. The pain was in the left lumbar region, attended with heat, not constant, but always present and troublesome when the stomach was considerably acid, and the heat always produced by the same cause. This pain was not absolutely confined to the same place, but was sometimes in the anterior, sometimes in the posterior, sometimes in the superior, and at other times in the inferior, but generally about the central parts of the lumbar region. It was sometimes attended with soreness or tenderness of the integuments. It is now about two years since it began. It increased for a time, and is now gradually diminishing, without any other apparent cause, than that the digestion of the patient is improving. A distinguished literary gentleman who was present when this was read to the Academy, has since informed me, that he was some years ago afflicted with severe Chronic Debility of the Stomach, for about two years, when his health began to improve, and continued mending till he entirely recovered; that during the prevalence of this disease, he had a complaint in the left lumbar region, almost exactly similar to the foregoing, and that he now recollected that it came on and went off, with the disease in his stomach, though it had never before occurred to him, that it was owing to that cause.

XI. An Irregular Pulse, &c. I have never known a good pulse, in a person severely afflicted with the disease under consideration. It is usually more frequent, feebler, and smaller, than in health. It is often irregular both as to force and time, sometimes beating three or four strokes with regularity, then a feebler and imperfect stroke; and sometimes after several regular pulsations, two or three hurried ones; sometimes intermitting once in six, eight, or ten pulsations; but with no regularity in any of these respects. I have often observed all these irregularities to be considerably increased, in one person, whenever acidity abounded in his stomach.

XII. LIABILITY TO BE AFFECTED BY CHANGES IN THE WEATHER. A person uniformly enjoying high health, can hardly form an idea of what is intended, under this head. He might almost as well conceive of the objects of a sixth sense. A gentleman who had been troubled with severe debility of the stomach, about a year and a half, went in the month of October, to reside in a large city, during the remainder of the autumn, and the ensuing winter. In consequence of various causes, his health rapidly improved. In the latter part of November, during several days of warm, foggy, relaxing weather, being engaged in close study, he became dull and spiritless, and his stomach was full of acidity. Finding himself too much indisposed to pursue his usual employments, he walked out one evening, very slowly, with his eyes fixed upon the ground, and his mind totally inattentive to the surrounding objects. After walking little more than a hundred rods, all his unpleasant feelings, which had been of three or four days continuance, were greatly mitigated, and soon totally ceased. On looking about for the cause, he found what he had not before observed, that the wind had changed to the north-west, and that the fog and clouds were dissipating, and the sky becoming clear.

The same person, during the latter part of December ensuing, was confined to his room, by ill health, about ten days. During five or six of the last days, the weather was extremely warm, damp, and relaxing, and the sky continually cloudy. This brought on a great degree of debility and languor. One evening at the close of this period, about nine o'clock, he felt surprizingly better, and instead of going to bed, as his ill feelings had prompted him to do, he sat up studying, till near midnight. He was utterly unable to account for his change of feelings, till, on withdrawing the window curtain, and opening his window, he found the wind had shifted to the north-west, and the sky had become clear. There had been no other apparent cause in either case, to produce the effects specified.

I have often experienced similar changes in my own feelings, from the same cause. Whenever the weather is cloudy, warm, and damp, I experience some degree of general debility. This is sometimes inconsiderable, at other times severe. In the latter case, my joints become relaxed; tremor affects my hands; the whole muscular, and nervous systems lose their customary tone; and a great excess of acidity takes place in the stomach. This is sometimes accompanied with wind, and various morbid sympathies, and sometimes not; and the ill feelings are occasionally so severe, as to unfit me for reading, and for any sedentary employment. They all also usually increase, till the weather changes. A change of wind to the north-west, will in most instances, dissipate the evil in a few hours. The languor and debility, the acidity of the stomach, the headache, the tremor of the hands, the hot flushes, the yawnings, the general irritability of body, and irresolution of mind which it occasions, speedily disappear. The weather most likely to produce these evils is that, which is so warm as to occasion a continued sweat from very gentle exercise, and so damp as to prevent the sweat from evaporating. A south-east wind, more frequently than any other, produces this kind of weather. After it, east, south, and north-east winds. A north-east wind is usually, cool and chilly, and far less unpleasant than a south east. I uniformly feel better after it begins to rain, than before. This kind of weather is very apt to occasion teethache, in dyspeptics. How can the rise and disappearance of acid in the stomach, from this cause, be accounted for, unles we admit that it is a secretion?

XIII. Habitual Discouragement. This is an almost universal consequence of Chronic Debility of the Stomach. I do not intend, that persons labouring under that disease, are at all times the subjects of such discouragement; but that almost all persons affected with it, are often, for considerable periods, in a greater or less degree, thus discouraged. This most unpleasant state of mind is greatly increased, and perhaps wholly caused, by acidity in the stomach. I have often observed persons of this stamp, regularly elated and depressed, as the paroxysms of acidity arose and disappeared, and have known but a very small number of persons, subject to severe and long continued attacks of that disease, who were of a resolute, decisive character. It is very difficult also, if not impossible, for a person who is called to encounter so many sufferings, as dyspeptic persons often are, to be habitually cheerful. Gravity, and some degree of sorrowfulness, seem to be the natural consequences of the disease. The stomach is a viscus exquisitely sensible, and has a singularly intimate connexion with other parts of the body. Of course, when its functions are deranged, many peculiar morbid sympathies are to be expected. For these, most persons are utterly unable to account. The state of the feelings is so strange, and so different from that which is experienced in good health; the actual distress is often so severe; so much indisposition is frequently brought on by slight causes, or by causes unobserved, and unthought of, by the subject of them; the complaints also, are of such long continuance, and so little relief is afforded, by the remedies customarily made use of; the sufferings of the patient are so universally treated with ridicule, or so often declared by others to be imaginary, while he knows them to be serious realities; the loss of strength and flesh, and the apparently hopeless situation in which he finds himself, are circumstances sufficiently disagreeable and alarming, to break down for a time, at least, the resolution of most men. In some instances, persons of high health, and sanguine constitutions, such as are very impatient of the complaints of dyspeptics, become from some of the causes beforementioned, themselves the subjects of this disease; and then, all that hardihood of mind, that decisive, resolute character, on which they prided themselves so much, and which they were fond of attributing to superiority of understanding, vanishes at once. Such persons, it appears to me, more than any others, are apt in this case to be extremely depressed in spirits, and difficult to cure. Such persons, more than any others, I believe, become finally deranged in mind, or the subjects of settled melancholy.

There are other persons, of a widely different character, who sometimes become dyspeptic, viz. such as are constitutionally phlegmatic, or made so by close and long continued attention to some one kind of business, and that of a nature which requires but little exercise of body, and furnishes little variety, relaxation, or amusement to the mind; who have never accustomed themselves to reading, or improving conversation, or to reflections on subjects which enliven the imagination, or improve the understanding. The minds and the bodies of such persons, are in a sense, usually in a state of stagnation.—When a person of this cast becomes the subject of severe Chronic Debility of the Stomach, the discouragement is so great, the torpor of the mind so entire, and the influence of the mind upon the body so commanding, that the chance of recovery is small. The patient dies as a candle goes out, because there is no more aliment to support the flame. The mind, it is hardly necessary to observe, has great influence in prolonging or shortening life. Such a person, cannot without much difficulty, be roused from his lethargy, he cannot be persuaded to make efforts for his own preservation, or if he makes any, he is utterly unwilling to persevere. He cannot find amusement in new employments, or if he can, he is wholly unfitted by his nature, or his habits, to make the experiment.

Firm fibres, and strong contractions of the muscles from the exercise of the will, seem to be almost indispensably necessary to great decision; yet I have known a very small number of men of very relaxed fibres, who possessed unusual energy of character. Health, and sometimes even life itself, in such persons, may be considered as a forced state, and as kept in being by the activity of the mind. Were such minds permitted to inhabit bodies of a different cast, bodies which, instead of continually retarding the mental energy, uniformly co-operated with it, a very commanding character would doubtless be the result. A person suffering from habitual debility of the stomach, will, of course, have relaxed fibres throughout, and feel muscular contractions ; and cannot possibly make the same advances in science, or acquire as great a mass of information, as one who does not labour under these evils, and yet possesses no more discrimination, or celerity of correct thought. The difference between the two men in these respects, after the lapse of twenty years, will be great, if both have made the most of their advantages.

XIV. Reverie. This state of mind, all persons labouring under this disease will, to a greater or less degree, slide into. Few causes so much increase acidity in the stomach, with its attendant consequences, as systematic thought. For ten years past, during most of the hot weather, one hour's attentive reading would, almost at any time, induce such an excess of acidity in my own stomach, with such an uneasy, gnawing sensation in that viscus, from the action of the acid upon the fibres, together with severe headache, and pain in the eyes, as to compel me to desist. Many hundred times has the effort been repeated, and almost as often relinquished. An hour is usually, and half an hour very often, the utmost extent of time to which the experiment can be pushed, during a day. The first sensation is considerable heat in the stomach, then the gnawing sensation above described, then flushes of heat, succeeded by darting pains in the head, fixed pain in the fore part of the head, pains in the balls of the eyes, then tremor of the hands, and universal debility. This continues through the day, and sometimes through two days, in very hot weather, unless thrown off by brisk exercise. But in cold and dry weather, I find myself often able to read two or three hours in a day, without much inconvenience. That such sufferings should discourage study, or the renewal of the cause of them, and draw the mind insensibly, and almost irresistibly, into a state of reverie, is not to be wondered at. Some persons of this stamp spend a great part of their waking thoughts, when they are not engaged in some active business, in humming tunes, or repeating a few lines of poetry. Several hours in a day, are not unfrequently passed in this manner. Though variety is so congenial to the feelings of man, yet here a dull uniformity, resembling a continued indistinct sound, is sought after, and the mind is satisfied, if it can escape the labour of systematic thought, to waste its hours on trifles. Severe suffering first leads to it, and in part continues it, and habit renders it agreeable.

There are other complaints, which, if they are not caused by Chronic Debility of the Stomach, or acidity of that viscus, are yet so intimately connected with the latter, in some instances, as to require the mitigation or removal of that, before any relief can be given to the principal disorder. Thus I have known one case of Chronic Rheumatism, and another of Gout in the feet, which did not yield to the ordinary treatment at all. They were both attended with excessive acidity of the stomach. This led to a suspicion, that they were so far connected with acidity, that they could not readily be relieved, but by removing that complaint. Vigorous and successful measures being taken for this purpose, the patients began almost immediately to mend.

After having mentioned the various evils, arising from the disease which has been the subject of the foregoing remarks, it will be proper to add, that one advantage usually results to those who are the subjects of it, viz. that they are less liable to attacks of inflammatory diseases.

We come in the last place to consider the TREATMENT.

The prospect of a radical cure depends on a variety of circumstances, such as the age and habit of the patient, the causes of the disease, the length of time which has elapsed since its commencement, and the habitual severity of the symptoms. A radical cure is, in many instances, rather to be hoped, than expected. On this account, the disease ought not to be styled, as it often is, the *Opprobrium Medicorum.* Many other diseases, originated by causes of no greater efficacy, are often equally obstinate. How many persons have brought on incurable weakness of the eyes, by an imprudent use of them, for a little time? How often has incurable madness been induced by severe study, or the indulgence of evil passions? Were a fifty-six pound weight appended to each foot, of a person sitting on a stool, he might without serious inconvenience, raise them from the floor for a few moments, but were he obliged to keep them thus elevated, beyond a given time, the muscles which were forced into this unnatural and violent exertion, would become debilitated to such a degree, that they would never again recover their strength; so if the causes which debilitate the stomach operate a long time, or with great severity, the fibres will not in some instances, ever recover their tone.

Those cases of the disease least likely to be radically cured, are found in persons in whom it is brought on in early life, and to a severe degree, and who possess an originally delicate and feeble habit, who are always strongly inclined to general debility; or in other words, persons in whom there is an original deficiency of vital energy.

When Chronic Dibility of the Stomach occurs in early life, from the attack of some acute disease, or perhaps from almost any cause, where the constitution is originally good, other things being equal, there is a fairer prospect of a radical cure, than in middle life, or old age.

Those on whom it has been induced by the abundant use of opium, or spiritous liquors, are less likely to recover, than many others, because after these habits have been long persisted in, it is difficult to persuade to a relinquishment of them; and because the system having been long accustomed to an unnatural and powerful stimulus, suffers great debility, and a sudden and alarming loss of vital energy, by the omission of it.

When it has been brought on by the excessive use of tobacco, though in many instances it is severe, and often continues a considerable time, yet so far as I have observed, it may more readily be cured, than in any of the cases hitherto mentioned. A speedy and total relinquishment of this habit, even after it has been continued for several years, I have not known to be injurious, but in various instances highly useful.

Where it has been induced by a too sedentary life, or by certain mechanical employments, merely, and without the co-operation of other causes, nothing more is usually requisite, except some immediate attention to the most troublesome symptoms, than a change to an active, healthy employment, provided early efforts are made of this nature.

Where it has been induced by severe study, if the patient is possessed of a constitution originally vigorous, and the study is for a time omitted, the cure is usually not very difficult. But the misfortune is, in this country at least, that of the young men originally destined to receive a liberal education, no small proportion are constitutionally feeble, and this is the very reason why they become students. It appears to be an opinion, prevalent to a great extent, among parents, that their feeble sons, if nothing else can be made of them, may be converted into scholars, and thus fitted to enter into one of the learned professions. No idea can be more erroneous. It requires far more strength of body to study effectually and thoroughly, than to labour on a farm, and not a small number of these very students, after dragging out several years of pain, disease, and discouragement, are compelled to enter upon some very different and more active business.

With respect to the length of time which has elapsed since the commencement of the disease, it can be hardly necessary to observe, that the longer it continues, the prospect of a cure usually becomes less.

With respect to the severity of the symptoms, it may be observed, that if the acidity and wind in the stomach are habitually severe, the prospect of a radical cure will be diminished, in some measure, in proportion. If the mind is greatly affected, and despondency, irresolution, and discouragement have taken possession of it, the prospect of recovery will be smaller, than with those persons, who are usually cheerful, and possessed of more mental energy.

In attempting a cure, we must, keeping the things which have been mentioned constantly in view,

1st. Avoid all the exciting causes.

It must be evident to every one, that so long as these causes continue to operate, the disease will continue to grow worse; yet nothing is commonly more difficult, than to persuade patients of the importance of attending to this direction. Against some of the causes they will without much reluctance guard, but to others, they will expose themselves with no small obstinacy. Study is usually so irksome, that most cease to pursue it with eagerness. A sedentary life is not unfrequently avoided, and great active efforts entered upon, but not a small number become so far discouraged, as to sit still more, and exercise less. Those, who habitually use opium, and ardent spirits to excess, very rarely reform. Tobacco chewers relinquish the use of this nauseous plant, with less reluctance. The indulgence of evil passions, instead of being repressed, as it ought sedulously to be, is often greatly encouraged, and thus brings with it a double present punishment. I cannot but think this cause to be more operative, than is generally supposed.

II. We are to mitigate or remove such symptoms as are especially troublesome. In cases where a radical cure is not speedily or at all expected, much may often be done, by faithful and persevering efforts to palliate the most painful symptoms.

The first and most troublesome symptom, and the one always demanding our attention, as being the cause of many of the rest, is acidity in the stomach and intestines. In endeavouring to remove or mitigate this evil, the objects to be kept in view are, twofold, viz. To remove the various causes which aggravate or induce it; and to rid the stomach of the acid, when it abounds to such a degree as to be troublesome.

1. The causes which induce a paroxysm of acidity, or increase the tendency in the debilitated stomach to generate it, are of two kinds, viz. primary and sympathetic. The primary are those, which operate immediately upon the stomach; of these, it will be proper to treat first.

Under this head, every thing relative to diet will be included. It will be proper to begin with that species of diet, which is most likely to produce acidity, and to close with that which is least apt to have this effect; or which, in other words, is most suitable for dyspeptic persons.

Though acidity has, I flatter myself, been shewn to be, in many instances, a morbid secretion, yet without great attention to diet, this complaint will frequently be greatly aggravated. The alimentary matter will readily undergo a fermentation. For whenever the stomach is debilitated to such a degree, as to secrete an acid fluid, the process of digestion will be so slow and imperfect, as to admit of a fermentation of many sorts of food, usually friendly to persons in good health; and perhaps also, the secreting vessels may have their tendency to morbid action increased, by every thing offensive to the stomach. Where the acid is occasioned wholly by fermentation, no one will contend, that very careful attention to diet is unnecessary.

The kind of food in general use in our country, which is most apt to ferment in the stomach and intestines of dyspeptic persons, and to occasion great quantities of acidity and wind in those viscera, is the acid summer fruits. Several of these fruits most dyspeptic persons can at times, eat sparingly, without much inconvenience.—Many such persons can, however, eat them but rarely, and then only in small quantities. Some persons are unable to eat them for years, and afterwards experience little inconvenience from a moderate use of them. The food which is at one period of life healthful, and much coveted, is, in some instances, neither agreeable, nor useful, to the same person at different periods, though his health may be good at both periods. This is much oftener true when the health is impaired.

All the acid summer fruits are apt to ferment in the debilitated stomach, and to generate much wind and acidity. Of those which grow in this country, and are least apt to occasion these evils, the St. Michael's pear, perhaps, stands at the head. Next to this may be placed several other species of pears, having a very soluble pulp, and a sweet, delicious juice, with the names of which I am unacquainted. Next to these are a few kinds of peaches, including those only, which are very sweet, soluble and juicy. To these, succeed a few sorts of apples, bearing the same general character. The purple raspberry takes the next place. Other kinds of raspberries succeed. Gooseberries, strawberries, currants, whortleberries, peaches of a middling or inferior quality, apples of the same character, cherries, plumbs, blackberries, and native grapes, being very apt to ferment in the debilitated stomach, should be used sparingly, if at all; and none of them, nor any of the other fruits can be safely indulged in, when the debility of the stomach is severe.—Every judicious person, however, can best determine for himself, on making a few trials, which are easiest of digestion, and whether his digestion is sufficiently vigorous, to render any of them safe. It ought to be added, that different persons do not, in all instances, find the same fruits easiest of digestion. It ought further to be observed, that in some instances, certain vegetable acids greatly relieve acidity. Thus I have known finely flavoured and pungent bottled cider, have this effect.

A distinguished medical gentleman has informed me, since writing the above, that, having somewhere seen a free use of ripe oranges strongly recommended for the relief of this complaint, he was induced in one case where all the usual remedies had failed, to give them a trial, and that his patient, a delicate lady, experienced great relief from this source. The fruit was not of the customary quality, picked green and ripened by decay, but uncommonly sweet and finely flavored. Did the vegetable acid so stimulate the secreting vessels as to excite a more healthy action? It surely could not have produced this effect by retarding, or preventing the fermentation of the alimentary mass.

Many kinds of apples and pears are rendered much more digestible, by baking or roasting. Fruits preserved in sugar, are less easy of digestion, than in the natural state. Of preserved fruits, several kinds of pears which may be kept through the winter, in their natural state, and prepared for use as they are wanted, and what is peculiarly important, may be made highly palatable with a small quantity of sugar, are perhaps the safest.

Of the garden vegetables, consisting of pulse, sallads, pot herbs, and roots, which are generally cultivated in this country, asparagus is, so far as my knowledge extends, decidedly the best. This observation would doubtless be thought a very strange one, by many of the inhabitants of the city of New-York, and of other places. The reason is this. All or almost all the asparagus sold in the markets of that, and several other towns, is cut in such a manner as to ruin it. That part only, or chiefly, is cut, which is below the surface of the ground, and this is always tough and bitter. That part only, which is above the surface, is fit to be eaten. This, when the weather is not very cool, and the growth of the plant therefore very slow, is always tender, if the root is of sufficient age. It should be cut just at the surface, when the plant is six inches high. It is surprising that so healthy, palatable, and productive a vegetable, should be so little cultivated, throughout our country, especially when we consider, that it comes at a time when few other vegetables can be had.

Summer beets and turnips, and summer and winter squashes, are usually easy of digestion. Of the last vegetable, the varieties being very numerous, and the qualities very different, pains should be taken to procure the best. Very good potatoes are usually sufficiently digestible, while those of a contrary character, often turn sour. The magic onion having the least of the peculiar odour, of that class of vegetables, and being very tender, often gives no trouble, when it is eaten without butter, or any other dressing, except salt and pepper. It is far superior to any other species of onion, with which I am acquainted; and has not been cultivated, I believe, till very lately, in any part of New-England, east of New-Haven, or at least to a very small extent only. Tender bean pods, or what are usually termed stringed beans, are rémarkably easy of digestion, and rarely give trouble to dyspeptics, except in severe cases. Shelled beans and peas are much less safe, and usually are made far more difficult of digestion than is necessary, by being eaten when old and tough, and with much melted butter. Maize boiled, or roasted, when it is young, tender, and succulent, is usually not only highly palatable, but safe and pleasant to the stomach; but when old and tough, it becomes highly, if not absolutely indigestible.

Throughout the country, it is to a very great extent, eaten when old and tough, and hence has arisen the common opinion, that it induces at times, diarrheas and dysenteries. By planting it at ten or twelve different periods, it may be had throughout the season, from the latter part of July, till the middle of October, and always tender, nourishing, and safe, for most persons. There is usually but one planting, as the use of it in this manner, is but a secondary object with people in general, and as but a small number of persons in this country pay that attention to gardening, which a regard to health, economy, innocent gratifications and pleasures so loudly demand. There is a vast difference between having at all times, an abundant supply of fine vegetables, and being confined to a few, and those poor, tough, and unpalatable. At boarding houses in our large towns, I rarely see any vegetables except potatoes, which are tolerable, and these are often water soaked. I have hence ceased to wonder, that so many healthy persons are prejudiced against the free use of vegetables, and content themselves to live on animal food, to so great a degree. From one planting of maize, a fortnight is perhaps, the utmost limit, to which the use of it may be extended, in a common season, even where you have the advantage of taking it from a large field, and where of course, it will not be all equally advanced. If eaten after this time, the gastric liquor makes no impression on it, and it passes the intestines absolutely unaltered. Tender parsnips are usually sufficiently digestible to be eaten with safety. Carrots are less so.*

Spinage, beet tops, and other greens, though often highly useful to persons in health, occasion too much flatulence, to be ventured on, by persons having weak stomachs. Boiled cabbage ought to be absolutely avoided, no vegetable within my knowledge, being so troublesome, in this respect. Lettuce, raw cabbage, celery, cucumbers, radishes, and melons, are all unsafe, and almost always prove troublesome to debilitated stomachs.

To all this it is proper to add, that persons labouring under the disease in question, cannot in many instances,

* See Note E.

with safety eat scarcely any of the foregoing vegetables, at certain times, and that some persons cannot for considerable periods; but this is only when the disease is particularly severe.

Nuts of every kind, and mushrooms, should be wholly avoided.

Of farinaceous food, good wheat bread is decidedly the best, for all persons having debilitated stomachs.—The flour should be of the best quality, and the bread well fermented, and thoroughly baked; and then it furnishes an article of diet, usually as safe, as it is palatable. But if all foreign substances are not separated from the wheat before it is ground, or if the bread is not well fermented, or if it is imperfectly baked, or too-much fermented, it will occasion acidity, or considerably aggravate it. If the bread is in a slight degree sour, whether from too long a fermentation, or from being made of sour flour, it will occasion distressing acidity. I have repeatedly known well fermented, and thoroughly baked bread, which was made out of sour flour, occasion excessive acidity, and severe costiveness, in a person previously enjoying very tolerable health, or in other words, having a pretty regular digestion, and open bowels; though possessing a stomach alway inclined to the production of acidity. In such cases the acid will not of course, subside on the cause being removed, but will in some instances, continue in the stomach, a considerable period; a little leaven leavening daily the whole alimentary mass, till relief is afforded, by an emetic, cathartic, or spontaneous diarrhea. Hot bread will almost uniformly occasion, and aggravate the same complaints, in the persons under consideration, and sometimes cause habitual headaches, where it is used daily. A gentleman of my acquaintance, who was dyspeptic, and troubled with very frequent sick headache, found entire relief from the latter complaint, by the disuse of hot bread, to which he had before daily accustomed himself. Persons having weak stomachs, ought never to eat bread, till it has been baked at least twenty-four hours. New bread is more glutinous and insoluble. The bread customarily made in this country, is by no means sufficiently baked. With all these precautions, and these are usually indispensable, they will sometimes find acidity increased by wheat bread. In that case, what are termed crackers, or hard biscuits, will usually give no trouble. Where these cannot be obtained, bread made in the common way, rolled thin, and twisted like certain kinds of cake, and baked dry, will furnish a good substitute. Bread prepared altogether in the common way, throughout the whole process, and, when two or three days old, broken up, or cut into slices, and then dried thoroughly, in an oven moderately hot, furnishes another substitute, and when pounded may be eaten in chocolate, or milk and water, or any other way which is agreeable, with great advantage.

The next kind of farinaceous food which is least likely to ferment in the stomach, is boiled rice. I have not known costiveness, or injury to the eyes, as has been alledged by some, to be occasioned by it. It is highly nourishing, and easy upon the stomach, and far less apt to induce acidity, than wheat bread which is not of a very good quality. Rye bread being alway disposed to ferment, and become sour, cannot be eaten with safety, by such persons as have debilitated stomachs. It often occasions when used at a single time, a severe paroxysm of acidity, and obstinate costiveness. For this assertion I may not perhaps, be believed. The celebrated Cullen has hurled an anathema against this opinion, by saying that he "will not believe on the authority of Hippocrates himself, that any of the Cerealia bind the belly." His belief, or his prejudices, make no alteration with respect to the fact. I can state, and state truly, that for ten years past, I have in no instance, within my recollection, eaten a meal of rye bread, without being made so costive as to need a cathartic after it, yet in various places where I have stopped, during journeys, I have at times been necessitated to eat it, or to go without food; so that I have made an abundant trial.

Every preparation of ripe maize, which I have met with, produces similar effects. The truth is, whatever occasions acidity in my own stomach, unless it also occasions brisk diarrhea, which is rarely the case, produces costiveness. Accordingly, as I have found from considerable experience, Lisbon wine, or any of the lighter wines, uniformly cause or increase costiveness in myself, while a few glasses of very good old Madeira usually relieve that troublesome complaint. The former becomes acid; the latter usually relieves acidity. It ought perhaps to be added, that rye bread, and the various preparations of maize, are commonly laxative, to persons whose digestion is unimpaired.

The only preparations of buckwheat, with which I am acquainted, are pancakes, which are fried in fat, and boiled puddings. No food can be much worse than the former, for debilitated stomachs; as it so quickly ferments, and turns sour, occasioning flatulence, costiveness, headache, &c. None of the other Cerealia are used as food in this country, within my knowledge.

Of other preparations of the several species of this class are, puddings, pies, and cakes. Of puddings, none but those which are very simple, should be ventured on.—Those only which I would recommend, are boiled rice, and boiled bread, previously dried and pounded. Flour puddings are too glutinous, and insoluble, and occasion, as do all the richer puddings also, in dyspeptics, the same disagreeable consequences. Every species of pie, and every kind of cake, except that which is very simple, are unsafe. It can scarcely be necessary to observe, that of the sauces customarily used with food of this sort, none except those of the simplest kind, are proper.

Of the effects of milk as an article of diet, I shall only remark, that so far as my observation has extended, it has uniformly proved mischievous to dyspeptic persons. It is too fluid, becomes highly acid, and occasions costiveness, headache, &c. Old pungent cheese often promotes digestion, while that of a contrary character, usually has a pernicious effect.

Eggs boiled to the consistence of thick cream, are usually safe and considerably nourishing, and very easy upon the stomach.

Fish are more nourishing, and more easy of digestion, than vegetables, and less so than flesh. Some kinds are much less digestible, than others. Broiled or boiled fish, are far preferable to those which are fried. Dried salted codfish, of a good quality, are usually friendly to weak stomachs. The shell fish are all, perhaps, difficult of digestion. Of those in common use, if I might judge from my own experience, the lobster is the least, and the clam the most so; but the experience of others does not in this instance correspond with mine. Few kinds of food are more troublesome to some dyspeptic persons, than the round clam: others find little difficulty from it. Lobsters should never be eaten warm. In this situation they often give trouble, when they would give none if cold.

Of domestic birds, the dunghill fowl, when young, is easiest of digestion, and the turkey the hardest. The latter is altogether unfit for weak stomachs; and indeed every kind of poultry should be sparingly used, by persons labouring under that evil.

Of animal food, and of all the food generally used in this country, good beef is usually easiest of digestion.—The reason why flesh is easiest of digestion, is very obvious. It is well known to every one, that that part of the alimentary mass which yields nourishment, must first become fluid, before it can have this effect. The fluid parts of animal food are already assimilated to our own, or in other words animalized; vegetable food must undergo this process, before it can be received into the mass of our fluids. The best beef is that which is as much as seven years old, and thorougly fatted, It should, when fresh, be roasted or broiled, in preference to being boiled. It ought always to be eaten rare, and never dried through. No gravy except the juices of the meat, or what is termed red gravy, is admissible. A very small quantity of fat is the utmost which is safe, fat in masses being always difficult of digestion, to debilitated stomachs. All these directions should be particularly attended to, when the disease is severe. Boiled beef moderately impregnated with salt, and beef smoke-dried for shaving, are as healthy as palatable.

After beef, mutton and veal are easiest of digestion. Fresh pork is altogether inadmissible. Salted pork, though not mentioned in this manner, within my knowledge, is usually when thoroughly impregnated with salt, whether broiled, or boiled, very easy of digestion, and often remarkably grateful. That which is not of the best quality, which is imperfectly pickled, or packed, and rendered rusty, will be nearly as offensive to the stomach, as it is disgusting to the palate. The lean part of pork hams, when properly cured, is usually grateful and healthy, to those having debilitated stomachs.

Broths, though very nourishing food, are improper in dyspepsia. They soon pass off into the intestines. The debilitated stomach needs the constant stimulus of food, the stimulus in quality, and the stimulus of distension to a moderate degree; otherwise the acid acts with so much force upon its naked coats, as to produce constant uneasiness. Broths also occasion in such persons, costiveness.

Drinks it is proper next to consider. Most of those in which a vegetable acid abounds, are hurtful to a weak stomach. All inferior wines, low beer, common cider, and strong undiluted porter, occasion much acidity and flatulence. Pungent hop beer, made bitter with hops, and stimulating with ginger, and replete with carbonic acid gas, is a healthy drink for very hot weather, when the perspiration is abundant; but in cool weather, it is less safe. Very pungent bottled cider is often highly serviceable, and safe, when most kinds of wine are otherwise, but not invariably so. Very sound old Madeira wine, drunk in moderate quantities, is in many instances, highly useful. It should be always laid aside, however, when it is not needed, as by constant use it loses a part of its efficacy; and all that efficacy will be wanted, whenever the debility becomes severe. When none of the foregoing drinks can be used without occasioning unpleasant consequences, pure French brandy, properly diluted with water, may be advantageously resorted to. As every man habitually using ardent spirits of any kind, is in danger of contracting an unsafe attachment, it will always be prudent for every person, to restrict himself within narrow bounds, and on no ordinary account, to exceed two or three table spoonfuls a day. Very pure old spirits may be used as a substitute. All other distilled spirits are hurtful; and whenever the stomach will bear other drinks, let these be immediately laid aside. The customary drinks in the morning and evening are, in this country, tea, coffee, and chocolate. Of these, tea of a moderate strength, mixed with a considerable quantity of milk and sugar, is perhaps usually the least apt to give trouble. Souchong tea is far less hurtful than the green teas. Coffee I have found, after repeated and abundant trials, uniformly to become highly acid in my own stomach. Chocolate made out of the cocoa merely, or with the addition of aromatics and sugar only, furnishes a very healthy and palatable drink. Most of the chocolate manufactured in this country, is very impure, and when prepared for drinking, is covered with oil, and wholly unfit for a debilitated stomach. Bryan Edwards, in his History of the West-Indies, observes—"The cakes which are generally used under this name in England, appear to me to be composed of not more than one half genuine cocoa; the remainder I take to be *flour*, and *Castile soap*." Whether that generally used in this country, is prepared of the same materials, I know not; but it is a very suspicious circumstance, that the chocolate made here, is usually sold considerably cheaper, than the cocoa, out of which it is made. Some adulteration or improper mixture must be the cause of it. The Spanish chocolate, and that which may be prepared in private families, out of the cocoa, may be had free from these evils.

Condiments, common salt, pepper, mustard, and horse radish may be used in moderate quantities, with advantage. Pickles, ketchup, and other sauces, and all expressed vegetable and melted animal oils should be wholly laid aside. I know of no food so injurious to a debilitated stomach, as melted animal oils. It would have been easy to have treated this part of the subject, in a more scientific way; but I have purposely avoided, as far as seemed proper, all technical terms, wishing to make the subject intelligible to such persons, as have not turned their attention to medical studies.

To the foregoing observations, it will be proper to add several other general ones, relative to the same subject.

All persons suffering from Chronic Debility of the Stomach, should be particularly attentive to masticate their food thoroughly. It has been ascertained by repeated and decisive experiments, that the gastric liquor much more speedily dissolves substances out of the stomach, when thoroughly comminuted. There is thus a much greater surface exposed to be acted upon. We may fairly and certainly infer the same, of the same fluid, when in the stomach. Much more nourishment is also derived from the same quantity of food when thoroughly masticated, than when not; and costiveness is much less likely to take place. He also, who masticates his food sufficiently, will seldom over-eat; while he, who swallows it without chewing, will, if his appetite is good, almost invariably eat more than his stomach can thoroughly digest. This will, if continued, infallibly weaken its coats, and induce costiveness.

With respect to the quantity of food, it may be observed, that the stomach should never be overloaded. To avoid this evil, he who has a debilitated stomach, should never suffer himself to fast, or go long without food, so as to become very hungry. To all such, late dinners are particularly injurious. The temptation to over-eat then, usually becomes so strong, that few persons will sufficiently command their appetites. The coats of the stomach become unduly distended, and thus the whole viscus becomes weakened; and the alimentary canal frequently filled with acidity and wind. Late and hearty dinners induce a feverish state, as is evident from the flushed face, the languor, the heaviness, and the quickened pulse, which take place immediately afterwards. Dinners should be furnished at an early hour. The food should be nourishing, and easy of digestion. Care should be daily taken, never to eat to satiety, but always to leave the table with a good appetite. Where dinner cannot be had at an early hour, I would recommend eating about twelve o'clock, or earlier, a crust of bread, or a cracker or two, with a little smoke-dried beef, or cold ham, or cold roasted beef, with a glass of Madeira wine. A very pernicious custom is extending itself, among fashionable people, in some parts of this country, viz. of dining at a very late hour, and eating three fourths of the whole food of the day, at dinner. It is reasonable to conclude, aside from all experience on the subject, that as the fatigues of the day, among such people, are chiefly before dinner, considerable food, and that of a nourishing kind, should be taken at breakfast; instead of the breakfast usually taken, viz. several cups of very strong coffee, with a little toast, or bread and butter.—To all dyspeptics particularly, I would recommend a far different course. Instead of eating immoderately at dinner, and taking a profusion of spices, and sauces, and drinking large quantities of porter, brandy, and wine, and thus unfitting themselves for thought, or business, the remainder of the day, let them make a more equal distribution of their food, at their different meals. Let them eat meat at breakfast; let them dine early; and then they will be inclined to eat moderately at dinner. In this way the stomach will usually fail of being filled with acidity and flatulence, and of being overloaded. The customary employments may then be pursued after dinner, as well as before. It will doubtless be supposed, that this course is not precisely suited to those, who lie in bed half of the forenoon. Only one kind of fresh meat should generally be eaten at a time. Salt pork, or ham, with fresh meat, I have not found hurtful. It is a good rule, however, to eat of but few dishes at once. Variety from day to day, may be useful, but not on the same day. Hearty suppers are always improper for weak stomachs: a few mouthfuls of cold meat, and a crust of bread just before going to bed, will often be of service. It prevents the acid from corroding the coats of the stomach, lessens or removes that unpleasant wakefulness which sometimes takes place in consequence of it, and relieves the sickness and faintness, which is by some persons experienced, on first getting up in the morning.—Where this complaint is troublesome, food should be taken immediately after getting up, or a little before.

Hot food or drinks are hurtful to the teeth, and weaken the stomach. Drinking large quantities of watery drinks, is always prejudicial to weak stomachs, and of stimulating drinks, dangerous. The quantity of drinks should be small, and little or nothing drunk between meals, unless in very hot weather. A large quantity of watery drinks may, perhaps, among other ill effects, dilute the food to such a degree, in some instances, as to occasion it to pass off too soon into the intestines. The persons for whom I am particularly writing, are very apt to drink more than is necessary or useful.

2. The sympathetic causes, which aggravate or generate acidity in the alimentary canal, are, cold and wet feet, such a degree of cold applied to the surface of the body generally, as will produce chilliness, a warm and damp air, the exposure of the eyes to the reflection of snow in a bright day, variable weather, an obstructed perspiration of the head from wearing pomatum and powder, inhaling an impure air, or rather swallowing it when mixed with the saliva, perfumes, wearing tight boots, ligatures, too much study or engagement of the mind, the indulgence of strong passions, and in a minor degree almost any thing which disorders the surface of the body, or any of the viscera. All these are to be guarded against. Cold and wet feet have a powerful influence in producing acidity and flatulence, in the debilitated stomach, where the alimentary mass is of such a nature as to ferment rapidly. Care therefore should be taken, to keep them uniformly dry and warm. For this purpose, boots with a treble sole should be worn, and within the boot a cork sole, covered with flannel; or a sole of an ox's bladder between the inner and the middle one. With this security any one may walk six or eight miles in the rain, or in wet snow, without endangering his health. To remove this morbid sympathy between the stomach and feet, I would recommend washing the latter, every day, in cold water. This practice should be adopted gradually, first using tepid water, and proceeding by little and little, to that which is cooler. It should be begun in the summer, and may by most persons be safely continued thro' the winter. He who will give it a fair trial, will find himself far less likely to take cold from wet feet, than before. Those persons who are troubled with cold feet, during the night in the winter, will find relief from holding their feet to the fire, fifteen minutes before going to bed. Frictions will also be useful. The exposure of the eyes to strong light often occasions much more disorder in the stomach, than an inattentive observer would imagine. I have re-

peatedly known much acidity and wind produced in that viscus, by the strong reflection of light from the snow in a bright winter day. Hence in walking, or riding, under such circumstances, the eyes should be in some measure defended. As variable weather, and a damp atmosphere are prejudicial, it will be advisable to fix upon a place for a stated residence, where these evils prevail in the smallest degree. A dry, sandy soil, and an elevated situation at a distance from the sea shore, is usually to be preferred. Some dyspeptic persons, however, appear to be benefitted by residing near the shore.— This is especially the case with some females, who usually reside in the interior country ; and who spend no small part of their lives in a rocking-chair, or about some employment which scarcely furnishes any amusement, or exercise. To such persons, I have repeatedly known a a journey, and short residence by the shore, highly useful. But the benefit here, though usually attributed to the friendly influence of sea air, ought undoubtedly to be attributed chiefly, and perhaps solely, to the exercise of the journey, to the novelty, variety, and amusement derived from an unceasing change of country, and that often a very beautiful one, to the conversation and kind offices of near friends, to the cessation of the usual domestic cares and anxieties, to an increased appetite, to a more generous mode of living, and a universal change of objects. A due degree of energy and exertion at home, would, in many instances, throw off the complaint also. An obstructed perspiration of the head may be prevented, by avoiding hair powder and pomatum, and by combing it with a sharp ivory comb daily, and brushing it with a stiff brush.

The efficacy of impure air in producing disorder in the stomach, appears to me to be much greater, than is usually admitted. Most persons appear to believe, that the danger to be apprehended from impure air, arises from the effect which it has on the lungs, in consequence of being inhaled. This opinion I cannot but think to be erroneous. In the month of October, 1804, I was requested to visit a man, living about thirty miles distant, who had a little time before, the misfortune to break his leg. Expecting from the information sent that an amputation would be necessary, I carried a set of instruments along with me. The day was cloudy, and very raw and chilly. I started a little before noon, and being straightened for time, imprudently did not stop to dine. I arrived about dusk. My stomach was empty and irritable, and I was desired soon after alighting to examine the wound. The fœtor proceeding from it was highly offensive. An extensive mortification of the fleshy parts around it had taken place, and the bone was to a considerable extent bare of the periosteum. While examining with my probe the more minute circumstances of the wound, it was necessary to hold my head very near. I was soon seized with severe sickness at the stomach.—Perceiving that I was becoming extremely faint, and should immediately drop upon the floor, unless relief was given, I made a desperate effort to reach the outer door, which I saw standing open. Finding no relief as I hastened towards the fresh air, but perceiving myself rapidly failing, I sprang through another door, two or three feet distant, and threw myself on to a bed, which lay near by, in an adjoining room. All sensation and voluntary motion ceased for a time, and when I revived I was unable to raise my head from the bed without relapsing into the same state. I continued in this situation about two hours, and though I have often fainted from a disordered stomach, and other causes, and suffered repeated fits of sickness, I have never in any instance, experienced from any disorder for so long a time, such a total prostration of the whole energy of the system. I did not recover from it that night, nor the next day, till late in the afternoon, when a consultation of medical gentlemen summoned at my request, by the attending physicians, unanimously advised to an amputation of the limb, which I proceeded to perform. The stimulus of the mind then overcame the disorder, and I never had more command over the muscular system, than on that occasion. The vitiated air of a crowded room I have often observed, to occasion and aggravate disorder in the stomach; or in other words, to generate and increase in it acidity and wind. Being an hour or two in a close room in warm weather, or in an open room where the circulation of the air is languid or interrupted, and the air of the room rendered impure by the respiration of a multitude of persons, has a very pernicious effect on my own stomach. The effect is too great to be wholly accounted for, on any other principle, than that which I have suggested, viz. a saliva rendered impure by mixture with a vitiated air, and received in that state into the stomach. Something ought undoubtedly to be attributed to the effect of the air on the lungs, from a deficiency of oxygen, and through the lungs upon the stomach, and whole system; and on some occasions something is to be attributed to long continued attention of the mind, and to weariness of the legs or body, from an inconvenient posture. On what other principle can we in many instances account for the typhus fevers generated in hospitals, and on board ships, and in jails, except from the operation of an impure air, swallowed with the saliva? Hence all persons having weak stomachs, should shun all crowded assemblies. Evening meetings, where it is necessary in many instances to stand till great weariness is induced, or to sit without support to the back, or in a cramped posture, and to inhale and swallow an impure air, are very injurious, and will often induce disorder of the stomach, which will not subside under three or four days. Such persons when called to visit sick rooms, should never go in with an empty stomach; or if that is unavoidable, should be cautious not to swallow their saliva when present. When called to watch with the sick through the night, they should keep a full stomach, and drink two or three glasses of good Madeira wine, or pure brandy and water. The contiguous effluvia, or the impure air when swallowed, will be so far diluted by the mass of food in the stomach, that it will be in a great measure inefficacious.

Too much study or engagement of the mind not only occasions acidity in the stomach, a fact which I know from my own experience, but also, as it appears to me, increases the irritability of the nerves, and renders them more sensible to the operation of the acid. On this subject I shall only observe further, that study before breakfast, and in hot weather by candle light in the evening, is extremely injurious. One hour spent in study at those periods, is more hurtful to a weak stomach, than three hours after breakfast. Strong passions often indulged, occasion in many instances, palpitations of the heart, headache, a loss of appetite, and universal debility. Every person prone to the indulgence of bad passions, should therefore watch with great care against their rise and exasperation. Aside from the stupifying influence which they exert upon the conscience, and the permanent injury done to the temper, a dyspeptic person cherishing bad passions, such as envy, jealousy and hatred, is the greatest of all fools, since he punishes only, or chiefly himself. A few minutes spent each day in meditating on the folly and wickedness of them, with daily resolutions to overcome, and the careful avoidance of all those causes which give rise to them, are proper remedies.

3. The remedies to lessen or remove acidity when it is formed, are, various preparations of the alkalies, lime, magnesia, chalk, and emetics.

Emetics are useful only when there is a mass of fermenting matter in the stomach, which needs to be evacuated. The mildest, as they debilitate the stomach the least, should be used for this purpose. Where the acid is formed habitually, unmixed with other acrimony, and unaccompanied with wind, or in other words where it is a secretion, emetics uniformly increase the evil they were intended to remove.

Lime water appears to possess no important advantages over the alkalies; and being astringent, is attended with some disadvantages with which they are not. Magnesia should be used only where a laxative effect is desired, because it disagrees with the stomach far more than the alkalies; and then instead of the small doses usually prescribed, two thirds or the whole of a tea cup full should be taken at once. A dose of this magnitude will occasion three or four evacuations, and remove in many instances the whole of the acid, and leave the stomach in a fit state for the reception of tonics. The best preparation of alkali I believe to be the soda water. This must be properly made in all respects; and to be of much efficacy in a severe case, must be taken in considerable quantities.

a substitute for this, the carbonat of potash, (pearlash) and the carbonat of soda, may be taken with advantage. A constant use of these, however, for a length of time will weaken the stomach. They may be taken in a watery solution, united with some agreeable stimulus, such as cinnamon water, essence of peppermint, essence of wintergreen, &c. or in the form of a pill. The former mode is preferable. After all these precautions, the acid will, in the stomach greatly debilitated, be formed or secreted anew, and other measures, to be mentioned hereafter, must be resorted to.

Flatulence, or wind in the alimentary canal, being occasioned by the fermentation of the food in the stomach, is to be lessened by avoiding all those kinds of diet which have been mentioned as apt to ferment. It may be removed, or greatly lessened, at any given time, by alkalies, and may be expelled in some instances by aromatics and other carminatives.

Rancidity in the stomach is to be relieved by one brisk emetic, and an alteration of diet.

Costiveness, by avoiding that species of food which is likely to ferment; and by many of those means which have been mentioned as lessening or removing acidity; and by various measures which will be mentioned when we come to speak of a radical cure. On this subject several further observations will be necessary. A respectable gentleman who has for several years suffered at times, from this complaint, which was connected with Chronic Debility of the Stomach, has lately informed me that he obtains entire relief from it, whenever he uses wheat bread made out of unbolted flour, that is, flour not separated from the bran; while rye bread and all the preparations of maize used as substitutes, occasion, or aggravate it. Having no experience on this subject, I shall make no comments upon it. To accomplish the same end, some persons resort to the frequent or constant use of cathartics, or injections. A gentleman long labouring under this complaint, and much reduced in flesh and strength in consequence of it, found entire relief from daily injections of warm water. This practice was continued many months, every day at first, and afterwards whenever a regular, spontaneous evacuation did not render it unnecessary, till at length the large intestines from habit, or some other cause, moved without any adventitious assistance. All the circumstances of this case I am unable to relate, and have not known the experiment fully made in any other instance. The frequent use of cathartics for the relief of costiveness, though often resorted to, is, usually, so far as my observation has extended, extremely injurious to dyspeptic persons. They generally greatly increase the debility of the stomach, and thus aggravate the complaint they were intended to remedy. The least mischievous cathartic with which I am acquainted, is the butternut pill; and I have known one instance, in which the long continued use of this medicine, proved highly serviceable. A gentleman who had been long afflicted with great acidity of the stomach, with obstinate costiveness and frequent attacks of cholic, used it every night just before going to bed, for seven months, in sufficient quantity to operate gently once the next morning, and drank daily six or eight glasses of wine, during the same period. His health in this manner was greatly improved. Some persons are disposed to think very favorably of castor oil in this complaint, as being gentle in its operation and usually sure. No mild cathartic with which I am acquainted, is, in my opinion so prejudicial to persons whose stomachs are much debilitated. All oils are unfriendly to persons of this description. A gentleman much troubled with complaints of this cast, and at the time affected with influenza, took a moderate dose of this medicine. Though it was of the purest kind, it induced such severe sickness at the stomach that he was unable for four hours to raise his head from his pillow without fainting. This effect was not owing to idiosyncrasy, but to acidity and debility of the stomach. Another remedy which has been recommended for the relief of severe costiveness is, washing the abdomen daily with cold water. I once knew this experiment fairly made, for a considerable length of time, and though it had the desired effect, it produced some evils which determined me in no case to recommend it.

The diarrhea which arises from acid summer fruits, &c. may be relieved by one cathartic, living on beef tea a day or two, and by astringents. To relieve the flatulence which is extremely troublesome in this complaint, a free use of carbonat of potash, dissolved in the beef tea, will be found highly serviceable. Taken in this way, it will not be found particularly disagreeable to the taste, nor will it disturb the stomach. It not only destroys the immense quantity of acid which exists in the stomach, and thus prevents an increase of wind, but it also destroys the whole of that, and in a little time, which has already formed. This I know from abundant experience.

The vertigo, pain and weakness of the eyes, the formation of tartar upon the teeth, teeth ache, catarrh, headache, disordered pulse, liability to be affected by changes in the weather, the depression of mind, &c. are only to be relieved by removing the acid, and restoring tone to the stomach, except that the catarrh may sometimes be considerably lessened by snuff, by combing the head daily with a sharp comb, and washing the neck with cold water: and the teeth-ache, and pain and weakness of the eyes, by bathing the face night and morning in cold water. This simple remedy has a powerful effect. The whole face should be dipped in a large bason of water repeatedly, and the ears and temples thoroughly washed. Gargling the throat and teeth with cold water will, also, have a similar effect, in part. A gentleman who has accustomed himself to face bathing for thirty years, has experienced these advantages, in a high degree.

It will now be proper to add a few *general directions*, relative to the treatment of Chronic Debility of the Stomach, which did not so properly come under any of the foregoing heads.

Particular attention should be paid to the dress. The clothing in our variable climate should never be extremely thin, but rather warm than otherwise. Any degree of chilliness is always hurtful. The clothing should be suited to the weather. In all sudden changes from heat to cold, additional clothing will be prudent, unless there was sufficient before to keep the body temperately warm, when sitting still. A flannel shirt should be worn throughout the year, next to the body. The dress should be made to sit throughout easily. Tight boots and shoes should be avoided. All ligatures to the neck, limbs, or body, as they impede the circulation of the blood, and cramp the muscles, are hurtful. Women far more frequently suffer from this cause than men, it being at times fashionable to lace and cramp the body to such a degree as to impede all the animal functions. I remember to have seen a lady, who suffered not a little from a debilitated stomach, and general weakness, who was affected for several days with palpitations of the heart, great faintness, and strange and in some respects alarming symptoms, alarming as the cause of them lay concealed, as the remedies used were wholly inefficacious, and the symptoms were daily growing worse. At length it was ascertained, that she had round the body a large bandage, very tightly drawn, which an officious friend had persuaded her to have applied to give support. This cause I had suspected on first seeing her, and made enquiries on the subject; but it was denied. On the bandage being removed, she became speedily well.

The daily use of the flesh brush, or card, is often beneficial. Indeed whatever excites irritation in the skin, will relieve the disease of the stomach. It is worthy of remark, though the fact is often met with, that a cutaneous eruption will, in many instances, give entire relief for the time, or during its continuance, to the stomach, and the digestion vigorous. Upon the same principle it is, that stimulating plaisters upon the epigastric region, are serviceable. Whenever the debility of the stomach is severe, a plaister of this kind will be found useful.—One six inches square will not be too large.

Persons afflicted with the disease under consideration, are extremely apt to sit and walk crooked. This, though it is often difficult to avoid, from the great debility of the body, should never be indulged as a matter of convenience, but sedulously guarded against. Such a posture habitually indulged, will certainly prolong and aggravate the complaint. Students and clerks should, when writing, stand upright at high desks, but not so long as to induce weariness of the legs. To prevent this, they may occasionally sit down. Neither is it advisable to continue so long at study or posting accounts, as to occasion confusion of thought, or weariness of body. A brisk walk of a mile or two will be found useful in such cases.

Sitting up late in the evening, or sitting where there is much light in hot weather, is also, not a little injurious. Many persons suppose, that the ill effects of sitting up late, are owing merely to our habits. This is a mistaken opinion. The truth is, after the fatigues of the day which most industrious people in this country undergo, whether they rise early or late, the wearied body needs *speedy rest,* and one hour's resistance of sleep at this period, will often be severely felt in its effects the next day. Dyspeptic people are very apt to sleep under too many bedclothes. So many as to occasion sweating, or uncomfortable warmth, will be injurious. Eight hours sleep is as much as is useful. The head should be kept cool and unencumbered with a night-cap. Watching with sick people through the night, or sitting up all night for any other purpose, is extremely injurious, and will in many instances produce a degree of acidity in the stomach, and general debility, which will not be overcome in a week. Having fires in our lodging rooms will expose us to take cold more readily. I hope that I shall not be censured, for dwelling so long, and with so much minuteness, on this subject, when it is remembered that not only the comfort of the diseased, but the vigour of their mental faculties, and their tempers and dispositions, are intimately connected with the state of the stomach.

III. We come now to the last thing proposed, viz. to remove that state of the stomach in which the disease consists ; or in other words, to effectuate a radical cure.

This is to be done by remedies which have an immediate operation upon the stomach, and by those which operate sympathetically, by strengthening the whole system ; or in other words, by exercise.

When the stomach labours under a paroxysm of debility, the mineral acids will in some instances be found highly efficacious, in restoring its tone. If taken in large quantities there is, however, danger to be apprehended to the teeth. Various preparations of bitters, with or without an astringent quality, are often of great service. To remove that extreme debility of the stomach, which occurs after a severe turn of diarrhea, or an attack of fever, I have found no medicine more useful than a powder composed of columbo root and pure rust of iron.—The relief found under such circumstances from taking it a single day, is often great, It may be taken in moderate doses, two or three times a day. Iron filings are preferred by some persons. Peruvian bark is very useful also, where it does not occasion costiveness, at least in many instances. Other preparations of iron may be resorted to, where for any particular reasons they may be preferred. Native mineral waters, containing impregnations of iron, may be used with great advantage. Of those particularly valuable in this country, the springs at Stafford and Ballstown stand at the head, at least so far as my knowledge extends. A free use of them and for some period of time, will be advisable. Factitious mineral waters resembling these, will be tolerable substitutes.—After considerable attention to the subject, I do not hesitate to say, that some or other of the ferruginous preparations, united with columbo, gentian, quassia, or some other of the bitters, are the tonics best suited to the case under consideration. When costiveness is occasioned, it must be relieved by some of the means before recommended; or the medicine may be laid aside for a few days, with advantage in some instances. Good Madeira wine will greatly aid the operation of the foregoing medicines. No wine but that which is of a good quality will be found serviceable. Wine, and wine only, is recommended in holy writ, for dyspeptic complaints. "*A little wine for thy stomach's sake, and thine often infirmities*," was the direction of the Apostle Paul to Timothy. The words "*thy stomach's sake, and thine often infirmities*," prove the disease to have been Chronic Debility of that viscus, with a numerous train of morbid sympathies; and no prescription of Hippocrates could have been better, for wine of the best quality is made in that part of the world where Timothy was, and in those days they probably had not learned the art of adulterating it.

These things are not to be considered as the great means of effectuating a cure, but rather as aids in the curative process. The disease when obstinate is not to be cured by medicines merely; and they who rely upon them solely or chiefly, will be disappointed. Still, when discreetly used, they are of great service. Some cautions relative to the manner of administering medicines, may not be improper. By persons having debilitated stomachs they should never be taken mixed with sweetmeats, but in the simplest state which circumstances will admit; that they may exert their full influence upon the stomach, and that their operation may not be counteracted or impeded by the acid and flatulence which sweetmeats occasion.

Previous to the commencement of a course of tonic medicines it will be proper to prepare the stomach for their reception by the administration of a cathartic. When the use of any medicine which is to be taken for some length of time, is about to be commenced, it will always be proper to begin with moderate doses. Large doses when the stomach is extremely irritable, excite irregular action, stimulate too highly, and thus fail of producing the whole of that efficacy which might have been in other circumstances expected. The quantity may be increased gradually as the case requires. While benefits are looked for from medicines, all other aids, those which have been mentioned, and those which remain to be mentioned, should be made to unite their whole force in counteracting the disease.

The curative process should be begun in the early stages of the disease, and pursued vigorously, before the secreting vessels have acquired such an inveterate habit of wrong action as they often do, where these directions are neglected. All persons admit that, when an ulcer has long secreted an acrid matter, vigorous measures are necessary to restore the vessels to healthy action, so when the vessels of the stomach have long secreted morbid fluids, very vigorous measures are likewise necessary to give relief.

The last and the great thing, which the patient is to depend upon for relief, is exercise. Connected with this some constant employment should be furnished, an employment requiring considerable exercise of body, without occasioning severe fatigue; which will moderately rouse and occupy the mind, without producing anxiety; which will excite hope, and furnish variety and amusement. The disordered mind has a real and important influence on the body and whatever promotes cheerfulness or inspires hope, benefits the health. Most dyspeptic persons being fond of secluding themselves from company, pains should be taken to draw them away from themselves, and to entice them into frequent conversation with cheerful and agreeable people. In connexion with this, other exercise must be taken of a pleasant nature, and as much as can be borne, without inducing severe fatigue.

In what way is exercise useful in such cases, it may be asked? I answer by strengthening the whole muscular system, and by improving all the secretions, but especially the gastric liquor and the bile; while it also diverts the mind from a dangerous attention to the disease of which it partakes, and frequently furnishes an agreeable novelty and variety. That exercise strengthens the muscles, may be easily evinced. Every one knows, that it increases greatly the circulation of the blood, and in this way an additional quantity of nutriment is added to the solids; it also sharpens the appetite, and renders the digestion more vigorous. Of course a larger quantity of nutriment is derived from a given quantity of food. The same truth is evident, from facts, obvious to every observer. Thus certain mechanical employments, which call into frequent or constant daily action, particular muscles, occasion in them considerable enlargement, and an increase of strength. The whole muscular system of a labouring man, other things being equal, is vastly stronger, than of a man confined to light and easy employments. That exercise improves the secretions, any one may be satisfied by attending to its effects upon himself. The secretion from the axillary glands it is well known, is greatly increased in quantity, and rendered far more odorous, by hard labor, or by any kind of exercise that moves the arm to an unusual degree, such as riding on horseback, cutting wood, &c. The sweat and ear wax of laboring people, is altered in like manner, and likewise, the milk of the female. The bile also is greatly improved in its quality, and often increased in its quantity, by the same cause. May we not reasonably infer the same of the gastric liquor?

Whatever be thought of this reasoning, the fact that exercise greatly benefits the health, will not be disputed. In many instances this alone, or in conjunction with a greater or less number of the several things before recommended, has effected a complete cure. Exercise increases the appetite, prevents acidity and wind from forming in the alimentary canal, removes costiveness, and thus destroys vertigo, head ache, pain in the eyes, catarrh, cough and discouragement; and greatly lessens or wholly removes all the other morbid symptoms. One day's riding on horseback will almost invariably relieve me from costiveness for the time, however obstinate, and a a long journey usually throws it off, for a considerable period. The worst case of stomach cough which I have ever known was wholly cured by riding on horseback a few days. I have also known repeated instances, of weakness and pain in the eyes, which regularly became better or worse as the patient increased or diminished his exercise. For man in his present state, that sentence denounced on him at the fall, that he should "earn his bread by the sweat of his brow," is one of the greatest temporal blessings ever conferred on him by his Maker. Exercise is the natural state of man. All healthy little children when suffered to pursue their own inclinations are, when awake, in almost constant motion.. As soon as they are able they set their hands and their feet, and their bodies in exercise. Those parents who tie their children in a chair, or confine them habitually in any way, do them a great injury.

How long a time should exercise be persevered in, it may be asked? I answer as long as life remains. The life of a person afflicted with severe permanent debility of the stomach is, like the christian race, a state of continual warfare. In many instances all that may have been gained hitherto, will without unceasing perseverance be speedily lost. He who has been once highly dyspeptic for a considerable length of time, however good his health may be at present, is, in most instances much more exposed to a return of the disease if he omit exercise, and the other precautions, than he whose health has never been impaired. This direction will I fear prove a stumbling block to some. Any measures however disagreeable which demand attention, self denial, and even confinement for a few days, many dyspeptic persons are willing to comply with ; but to persevere in this course many months, and years, is an undertaking too arduous to be generally looked for. No small proportion of them are fickle, as to the measures they adopt for recovery. Some of them go from physician to physician, till perhaps they apply to all in their neighborhood; when they sit down with this melancholy conclusion, that no one understands their complaint, or that it is incurable. This arises in part from the ridicule and contempt so often manifested by physicians, about complaints of this nature, from a persuasion that they are in a great measure imaginary, and from the general conclusion that *nervous disorders* are incurable ; and in part from the patient's expectation that the cure will be as speedy, as that of any acute disease. Some years ago a young man, son of a respectable farmer, having been between one and two years the subject of great debility of the stomach, applied to me for advice. He appeared wild, was easily alarmed, almost ready to despair of recovery, and was in great danger of a confirmed delirium. During his indisposition he had already applied to six or eight physicians, all of whom had treated him much in the same way. They seemed to consider his complaints as imaginary or mental merely, told him he was nervous, and that the cure must be looked for from time, and the efforts of nature. They advised him to cease from work, to ride about home and amuse himself. The medicines in each case were very inefficacious, and designed to amuse, rather than to cure. Finding the measures of the first producing little or no beneficial effect, he went to the second, and then to the third, and through several others, till his father brought him to me. At the outset he was gratified not a little, by my telling him that the disease was not an imaginary but a real one; that it was not mental merely but that it had its seat in the alimentary canal. He was affected with several unusual and anomalous symptoms. I explained to him as far as I thought he would comprehend, what I supposed to be its nature; that it was far from being as he apprehended very peculiar, but on the contrary that it was very common. I also expressed strong expectations, that if he would pursue the course to be pointed out to him, for a sufficient length of time to give it a fair trial, he would entirely recover, and within a moderate period. Having gained his confidence, I gave the necessary directions relative to his diet, dress, &c. ordered him a cathartic to prepare his stomach for the reception of tonics and stimulants, and at the proper time commenced the use of chalybeates and bitters. With this he was directed to drink daily several glasses of pure wine. He was directed also to go into the fields daily, with his father and brothers, and work as much as he could without severe fatigue, to engage in light work, to ride on horseback whenever business could be found for him, and to keep constantly employed and by no means to saunter about as he had done for a long time. He had originally a good constitution, and in three months became robust.

What kind of exercise is best adapted to dyspeptic people?

Generally speaking, exercise in the open air, is preferable to any that can be taken within doors. Of the former kind, riding on horseback is, doubtless, superior to any other. This agitates the body universally, and the abdominal and thoracic viscera peculiarly. No other reaches the spot so certainly, and so efficaciously. To gain the utmost advantage of this, the patient should in every severe case, take long journeys, because the system requires a great change to be wrought in it, because he will then have no excuses for sitting still, and because unceasing variety and novelty are thus presented to him. In all cases it is desirable to journey with a cheerful and intelligent companion, and in some instances the direction and conversation of some discreet person is indispensable. Such persons as can find unceasing gratification in beholding a beautiful country, in surveying lofty mountains, and rich vallies, wild and rugged precipices, majestic forests, noble rivers, well cultivated farms, neat villages, thriving and prettily built towns, a never ceasing and perpetually varying verdure, and that universal cheerfulness and beauty, that air of contentment and good order, which New-England presents, and who when outward objects fail to attract their attention, can find serenity within, who having abundant resources in their own minds, can in solitude find company, and dwell with delight on the highest and noblest subjects of contemplation, may journey alone. But those, who, when alone, spend a large part of their time in poring over their disease, who are unaccustomed to extensive thought, and find little delight in the great and interesting objects of the natural world, and when called to exercise by themselves, consider it as a task which they are required to go through, are utterly unfit for such an undertaking. Neither the cold of winter, nor the heat of summer, furnish suitable weather for journeying. From the 10th of May till the 1st of July, and from the 10th of September till the 1st of November, are the best periods of the year.—On returning, the same, or some other exercise, must be resorted to daily. Ten miles riding every day when the weather will permit, is the least which will answer. Unfortunately it is not perfectly genteel to ride on horseback, especially to take journeys in that manner, but it is altogether so, to be cramped up in a close carriage, shut in from the least view of the country, and necessitated to inhale through the day an atmosphere, rendered highly impure and offensive by the respiration of ten or a dozen persons. Where daily riding in the manner recommended above cannot be pursued conveniently, digging and hoeing in a garden will prove good substitutes; or as the patient is able to bear, almost any sort of labour which is customary on a farm. Walking, as it agitates the stomach and intestines but little, and if pushed to a considerable extent occasions weariness of the limbs, is far less serviceable. It is however desirable for every one to accustom himself to walk freely and every day, when other exercise does not prevent. Riding in a carriage is sufficient for delicate females, and little children.

A sea voyage has in some instances proved highly serviceable. There are however several objections to it. It is very apt to occasion obstinate costiveness, and furnishes no variety, or amusement. Should it be determined on, the patient should not go as a mere passenger, but should do all the labours of a common seaman, so far as his strength will permit. A gentleman of my acquaintance, who possessed originally a fine constitution, but in consequence of close study for a considerable period of time, and an almost total abstinence from exercise, became the subject of the disease under consideration, effectuated a perfect recovery, by rowing a boat daily about two hours. This practice he continued so long as he found it necessary, and occasionally took other exercise of various kinds.

In cool weather, cutting, sawing, and splitting wood, will be found very useful. Riding in a sleigh will usually be of no service, and by occasioning chilliness, and pain in the eyes, will often fill the stomach with acidity. That species of motion will also occasion in some persons, vertigo and nausea. For young men at colleges or in merchants' counting-rooms, playing at ball, foot-ball, quoits, nine-pins, and various other similar amusements, will be highly useful, But it has been long a desideratum to find out some exercise which could be conveniently taken within doors, when the weather is stormy and unpleasant. Several persons have recommended with this view the swinging of weights. This is to be done in the following manner: Take two 14 lb. or 7 lb. or smaller weights, one in each hand; let the arms hang down in the natural state. Elevate them suddenly as high above the head as can be done with convenience: as suddenly bring them aside the body to their former place: continue this motion till the arms become weary. This exercise may be repeated often during the day; and may be varied by bending the knees, whenever the weights are brought down, so as to bring the latter about half way distant between the knees and the feet. Not satisfied with this, I tried another kind, which I thought preferable. Take four flat irons, (sometimes called sad irons.) Tie them in pairs face to face with strong cords. A piece of stout brown paper should be put between, to prevent their slipping, and made to extend over the corners, to prevent their cutting the cord. Then take one pair in each hand, by either handle. Let the body be entirely erect, and the arms hang aside the body as before. Suddenly elevate the irons as high above the head as can be done conveniently, keeping the arms pretty firmly extended the whole time; immediately bring them down again, and carry them as far behind the body as ease of motion will admit. Repeat the process till weary. This not only exercises the arms and shoulders briskly, but also the chest and whole body, and it will be well to elevate the feet each time. It may be repeated often during the day. Care should be taken when it is first attempted, not to push it too far, as it will occasion lameness in the shoulders. It had this effect upon myself, and on a friend of mine, whom I persuaded to give it a trial.—But after ten or twelve days I was able to pursue it to a considerable extent without inconvenience. I now daily resort to it, as a part of my habitual exercise, and find great advantage resulting from it. It has an excellent effect on my chest, and will, I am persuaded, cure me of tremor of the hands, by the strength which it will communicate to the arms and body. The longer I continue to make trial of it, the higher is my opinion of its efficacy. Instead of four flat irons, two weighing about ten pounds each, would be preferable, or two wooden blocks made of heavy wood, and shaped tike the head of a beetle, with suitable handles, might perhaps answer as good substitutes. I would also recommend the swinging of a 56 lb. weight, in the following manner: With both hands grasp firmly the handle, previously covered with cloth, or paper, place the feet from eighteen to twenty-four inches apart: swing it forwards and backwards. Some other species of house exercise seems to be necessary for females, especially for those who labour under Chronic Debility of the Stomach. Women in this part of the United States, though their daily employments are sometimes sufficiently fatiguing, take but little exercise in the open air; hence they are very slow in recovering from that disease. No house exercise for females, is better than spinning on the large wheel. Playing at Battledore will be occasionally a good substitute. Being much over the fire in hot weather, should be carefully avoided.

With respect to the quantum of exercise I would observe generally, that persons who are much debilitated, or unaccustomed to an active life, should begin moderately, and increase as their strength increases. Several medical writers of considerable respectability, have asserted, that, *to continue exercise till free sweating is induced, is hurtful.* With this opinion I cannot agree. On the contrary, I have uniformly found, and in a great number of cases, that exercise was of much less service where this effect was not produced, that is, in warm weather: Should it be occasioned chiefly by extreme heat, though with the aid of gentle exercise, I acknowledge it may prove prejudicial; as it may also, if the patient is much debilitated, and it is continued so long as to produce great weariness; but where a tolerable degree of strength remains, and he has been accustomed to exercise, between one and two hours brisk hoeing in a garden before breakfast, so as to occasion the sweat to drop freely from the forehead, will, instead of debilitating, greatly increase the appetite, promote digestion, and speedily give a universal tone to the muscular system. If he will proceed as his strength will permit, to work through the summer more and more, and to accustom himself more and more to hardships, he will be not a little benefitted. It has repeatedly happened, that rich men, severely afflicted with Chronic Debility of the Stomach, and living in a state of indolence and torpidity, with an intention merely to enjoy the good things of this life, without sharing in any part of the curse denounced on man at the fall, have in consequence of being reduced by some misfortune to poverty, been compelled to labour for their daily subsistence, or to lead a very active life, and have thereby become healthy and energetic.

With respect to the time of the day which is most suitable, it need only be observed, that in hot weather, in a pure country residence, where noxious exhalations do not prevail, that is, in such a country as New-England, early in the day before breakfast, is the best time; and after breakfast in the forenoon, whenever the heat is not oppressive; but it will be well for every one to accustom himself to exercise at any time of the day, except soon after dinner, as early and as fast as may be. It would be a good rule for all to adopt, to eat with so much moderation, that light exercise immediately after dinner, should not be burdensome. When riding on horseback in cold weather, the body and the feet should be so well guarded, as to prevent chilliness, otherwise the stomach will become disordered, and little benefit will be derived.

NOTES.

NOTE A.

S. W. was some years ago affected with severe cough, expectoration, night sweats and other complaints, to such a degree, that he was supposed by his friends to have a pulmonary consumption, and to be rapidly declining. One day being intently thinking on some subject which interested him, he involuntarily took a sharp comb, which lay upon the shelf, near which he was standing, and scratched his head with it briskly. He observed that a very great quantity of dandruff fell from his head, and he was led in consequence of it, to comb it thoroughly and frequently, and by this means all his hectical symptoms left him, and in a few weeks he perfectly recovered.

NOTE B.

In the month of February 1775, a young gentleman aged about 21 years, lay very sick of a fever, in his father's house—he had been sick about a week, and was unable to raise his head from the pillow without fainting. At this time, he overheard some one of the family mentioning that one of the mobs so frequent at that time, and which grew out of the disorderly spirit of the country, and were gathered from several of the neighboring towns, had threatened to pull down his father's house, and were already on their march for that purpose. His father had left the town, and his eldest brother was sick in the house, of another disease. On hearing this intelligence, and realizing the situation of the family, he he instantly sprang from his bed, dressed himself, barred the doors and windows, and loaded several muskets, which were near at hand. He then called for two hired men who were in his father's employ, to stand by him and defend the house and family. During the whole period he manifested the utmost coolness and the most determined bravery, declaring that he would do no injury to any man who was quiet, but that he would shoot the first person that offered any violence to the family or house. No such violence was offered, for though the mob came, they directed their zeal to other objects. The disease however was broken and never returned. He continued from that time perfectly well, and pursued his usual business without the least difficulty or interruption.

NOTE C.

Since writing the above, I have read cursorily what Fourcroy has written on the Gastric Liquor. He states that several physiologists assert that they have found that fluid acid, and that this has been the case, when it has been discharged by natural vomiting or by vomiting from an emetic; and that it has also been true of the liquor found in the stomachs of animals opened for anatomical observation. He further states, that Citizen Goffa, (elsewhere written Gosse) observed his own gastric juice had a well marked acidity, when he had eaten crude vegetables.

The amount of all these declarations seems to be nothing more than this, that various persons have found an acid mixed with the gastric liquor: a fact which the first physician that ever knew there was such a liquor, and ever saw a person spontaneously vomit, could scarcely fail to admit.

NOTE D.

Of the first kind of diarrhea, the following case may serve as an example. A young gentlemen some years ago confined himself to study, for about three years, as much as ten or twelve hours a day, with almost no exercise. About the beginning of the third year, in the month of May, as the weather grew warm he became considerably debilitated, his digestion was languid and his appetite poor. He was also uniformly costive. These unpleasant symptoms increased through the summer and autumn. In the month of February, in the ensuing year, he became much more unwell, in consequence of sitting two or three hours one evening with wet feet, in a cold room. This brought on a very severe cough, and a light fever and a great increase of debility. He continued to grow worse for six or eight weeks, and his complaints were so obstinate and so little relieved by the medicines made use of, that his friends became apprehensive about the consequences. In April he began very slowly to mend, but was unable to leave his room till about the beginning of May. He then every pleasant day, accustomed himself to walk as far as he could without inducing much fatigue. He gained strength very slowly. His diet was not sufficiently nourishing, nor were any tonic or stimulant medicines made use of. The physician who had attended him had given no directions relative to these subjects, and neither himself nor his friends were sufficiently aware of the importance of adopting vigorous measures for his relief.—When he had acquired strength enough to walk out, he began to be afflicted with almost continued nausea. This evil attended him from the time he awoke in the morning, till he got asleep in the evening, except during a quarter or half an hour after each meal. The sensation at the stomach, he described as very exactly resembling that, in kind and degree, which results from taking an emetic about five minutes before it occasions vomiting. For this complaint, his physicians prescribed emetics, but they proved of no service; the stomach being so extremely torpid, that vomiting was not in any instance excited. They appeared to have no other effect, except to debilitate, and to increase the evil which they were intended to remedy. From the first of May, till about the middle of September, he had very few or no natural stools. During this time he was obstinately costive, except for short periods. At these periods he was in a state of severe diarrhea. For the costiveness cathartics, of what kind I know not, were administered every other day and nothing passed his bowels, except in consequence of them, only during the turns of diarrhea. These were brought on in every instance by eating acid fruits or pies, came at nearly regular intervals, continued about four days, and occasioned each from forty to seventy stools. The stomach was continually filled with acid, He was afflicted with a severe gnawing sensation, distension of the intestines and cholic pains, acid eructations, vertigo, headache, frequent teeth ache, incessant catarrh, tremor of the hands, occasional syncope, palpitation of the heart, yawning, sighing, a pulse always irregular, both as to time and force, and frequent intermitting copious and debilitating sweats. The sweat upon his forehead, during the whole summer, induced by brisk exercise, had a strong acid smell, his spirits and energy of body were greatly affected by changes in the weather, he was subject to great drowsiness, his sleep was laborious, and he dreamed every night, during all the time in which he slept, but he was never able to give any connected account of his dreams when he awoke. His countenance was remarkably leucophlegmatic, and his spirits much depressed. During the summer he studied every day as much as he was able, usually about five hours; and walked and labored as soon as his strength would permit, three or four hours a day. In September and October he journeyed on horseback, about five hundred miles. This greatly improved his health, for a time. His digestion became good, and his spirits cheerful. All his unpleasant symptoms disappeared. For about two months he studied as much as he had formerly done.—During this period he resided from home, and was in a great measure deprived of exercise, and cheerful company. His food also was, to a great extent, such as was very improper, and tended to aggravate his complaints. In a little time, most of his dyspeptic symptoms returned. The diarrhea was about as frequent, and about as severe at the onset of each attack as before, and continued to return for about ten months. Being called to attend to this case, and finding that the usual remedies had given very imperfect relief, and that the stomach and intestines were so exceedingly irritable that a single tea spoonful of preserved fruits, or a small piece of a pye, a cake, or a small quantity of acid summer fruits, would induce diarrhea at times, and much wind and acid always, thus converting the contents of the stomach and intestines into a mass of acrimony, and that acrimony irritating the languid secreting and absorbing vessels with which it came in contact, I became satisfied that the principal immediate relief for the diarrhea must be looked for, from the use of such food as would be nourishing, and unapt to ferment in the stomach; such as would dilute the acrimony, and by its mildness, quantity and fluidity, defend the inner coat of the intestines, from the irritation heretofore experienced. The diet made use of was beef tea, and it answered the purpose remarkably well. Every paroxysm became shortened in consequence of it, as much as two or three days, and instead of the numerous evacuations abovementioned, they were lessened in number two thirds or more, and these were less copious and irritating than before. The patient was confined absolutely to this diet, while the diarrhea lasted, except that he was allowed to drink a little pure brandy and water. Rest or the avoidance of exercise was also highly necessary, and strictly enjoined; if at any time this course was dispensed with, the attack was as severe and as long as before. From a change of diet, and an increase of exercise, and other causes, the patient became toward the close of the year, more healthy, and now, during a turn of diarrhea, the beef tea is of no service.

NOTE E.

A gentleman, whose digestive powers were exceedingly impaired, and whose stomach was filled with a most corrosive acid, so that whenever he vomited, which he did often, his throat became excoriated to such a degree, that luke-warm milk and water occasioned considerable pain in swallowing, took large doses of Hull's cholic powder, a cathartic composed of aloes and aromatics. This produced copious evacuations from the intestines. Among the foecal mass, were observed, a large number of pieces of carrot, which were washed and found unaltered; yet he had not eaten any carrots within three months from that time. I do not suppose this to have been occasioned, by the peculiarly indigestible nature of the carrot, but chiefly by the excessive torpidity of the digestive powers. This fact, however extraordinary it may seem, may entirely be relied on.

In consequence of the Author's residence being *now* at a distance, several errors have occurred.

ERRATA.

Page 221,	line 32,	for *up*, read *upon.*
223,	- 30,	dele *a* before *Chronic.*
228,	- 13,	for *phenomenon*, read *phenomena.*
233,	- 22,	for *han*, read *had.*
236,	- 1,	for *prima via*, read *primæ viæ.**
239,	- 9,	after *acid eructations*, insert *acrid eructations.*
245,	- 22,	for *frequent*, read *frequently.*
251,	- 38,	for *alterations*, read *alternations.*
252,	- 5,	after *at times*, insert *secreted.*
263,	- 2,	from bottom—after *to do*, insert *before.*
267,	- 2,	for *feel*, read *feeble.*
281,	- 27,	before *Condiments*, insert *Of.*
287,	- 31,	for *contiguous*, read *contagious.*
289,	- 1,	for *a substitute*, read *As substitutes.*
292,	- 29,	after *and*, insert *render.*
299,	- 33,	for *choracic*, read *thoracic.*
306,	- 18,	for *Goffa*, read *Goffe.*
308,	- 5,	for *frequent*, read *frequently.*
idem	- idem,	after *intermitting*, add a comma.

* *This phraseology, though false Latin, custom has authorized.*

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No. XIX.

A DISSERTATION

ON THE

ORIGIN OF SPRINGS.

BY SERENO DWIGHT, ESQ.

PHILOSOPHY has long been deſirous of inveſtigating the *Cauſes* of things; but has uſually made ſlow progreſs, where the *modus operandi*, or the connecting link between cauſe and effect, could neither be *ſeen* nor *felt*. To explain the phenomena of Thunder and Lightning, ſhe firſt created a Jupiter, and then forged his thunderbolts. For the cauſe of Tempeſts, ſhe reſorted to the influence of the Stars. And HERODOTUS very gravely tells us, that the return of the Sun from the ſouth, after the winter ſolſtice, is owing to the prevalence of a violent South Wind in Egypt.

The *Origin of Springs* is a ſubject of this *inviſible* and *impalpable* nature; and, as might have been expected, has long agitated the Republic of Letters. ARISTOTLE informs us, that the air, which is incloſed in the vaults and caverns of the Earth, is condenſed into water near the ſurface; and thence flows out in ſprings. In the preſent ſtate of ſcience, probably, no one will think, that this ſcheme needs a refutation. Many authors, however, who have treated it with an unbecoming ridicule, would have ſpared their wit, had they known, that their own hypotheſes, deviſed more than two thouſand years afterwards, were deſtined to a ſimilar fate with that of the Grecian Philoſopher.

The Modern Theories may be reduced to three claſſes.

They all find the reſources of Springs

In the Ocean ;

In an Abyſs, in the bowels of the Earth ; or

In Vapour.

Thoſe, who draw the water of Springs from the Ocean, have been puzzled to convey it to their orifices in the ſtate in which we actually find it. Springs are uſually freſh : the Ocean is ſalt. Moſt Springs are higher, and ſome many thouſand feet higher, than the level of the Ocean. To raiſe their ſupplies requires, therefore, a force ſufficient to counteract the force of Gravity.

Theſe difficulties, attending the firſt claſs of theories, have coſt its advocates no ſmall expence of labour and ingenuity. Des Cartes, to avoid them, kindled a fire in the bowels of the Earth, by which he converted the water of the Ocean into Vapour. This Vapour, he collected in hollow ſubterranean caverns, and theſe condenſed it into water. Some of his followers, diſpenſing with theſe caverns, raiſed their vapour thus formed through the interſtices of the ground, until it was condenſed by cold near the ſurface. Had Des Cartes and his diſciples adopted the rule, which afterwards directed the reſearches of Newton ;

Never to aſcribe a phenomenon to any cauſe, until the exiſtence of that cauſe is proved ; their ſubterranean fire would never have been kindled. Perhaps, alſo, they would have found the remote cauſe of ſprings in the heat of a very different fire ; kindled, not merely in the imagination,—and by the hand of One, all whoſe theories are only practical.

The exiſtence of this ſubterranean fire is a mere hypotheſis,—wholly unſupported by proof. So far as the interior of the Earth has been explored, its temperature below 1000 feet has been found, in all latitudes, to be about 50° of Fahrenheit : a temperature, which will appear wholly inconſiſtent with the exiſtence of ſuch a fire, if we attend to the following facts.—The Rivers now running have probably flowed ever ſince the Deluge ; and the quantity of water, which they now diſcharge, has doubtleſs been their average ſupply. Vapour is found to loſe 1000° of heat, when condenſed to water : and water abſorbs the ſame quantity, when reconverted into vapour. According to the theory, the vapour muſt riſe, before it is condenſed, at leaſt as high as the Springs which it ſupplies. What an incalculable quantity of heat muſt then have been diſcharged near the ſurface of the Earth, in order to ſupply the rivers with water ſince they firſt began to flow. This heat muſt have been conſtantly accumulating near the ſurface, during ſo long a period. Why, then, is it no where diſcovered ?

Others have attempted to avoid theſe objections, by calling in the aid of *capillary attraction.* As water is known to aſcend in *glaſs* tubes of a very ſmall bore, it is concluded that it may alſo aſcend through ducts in the Earth of a ſimilar ſize. Hence the exiſtence of ſuch ducts, and the aſcent of water through them, are taken for granted. The Springs, which feed the Amazon, are ſeveral thouſand miles from the Ocean ; and many of them iſſue from two to four miles above its level. He, who can believe, that the interior of the Earth is thus furniſhed with an apparatus of natural capillary aqueducts running horizontally thouſands of miles, till they meet a mountain fit to harbour a ſpring, and then aſcending perpendicularly to an orifice ; has faith enough and to ſpare.

But if theſe ducts actually exiſted, they would not explain the phenomena of Springs.—To whatever cauſe the riſe of water in capillary tubes is owing ; whether to the attraction *of the whole interior ſurface* of the tube ; or to the attraction *of the ring of glaſs contiguous to the* *upper surface* ; Reason demonstrates, that such a tube cannot *raise* more water than it can *sustain* ; since the nearer the fluid is, the stronger is the attractive force. Experiment confirms this conclusion ; for a capillary tube, however short, cannot be made to run over.—The force of capillary attraction, also, will raise water but to a very moderate height. The proposition found in most Treatises on Hydrostatics—*That the height to which fluids rise in capillary tubes, is inversely as the diameter of their bores*—has led many to the erroneous conclusion, that if the bore is indefinitely small, the fluid will ascend to an indefinite height. But the fact is otherwise. Dr. HOOKE, after many experiments with what he calls *cobweb tubes*, was unable to raise water in them more than 21 inches.—Should we, therefore, suppose such ducts to exist in the earth of the requisite length and position, capillary attraction would not raise water in any of them to a greater height than 21 inches ; nor, even in those of a less length, would it cause the fluid to run over.

Others allege, that if a small heap of ashes or sand is put into a bason of water, the water will rise through it, above its own level, to the top of the heap. They compare the Dry Land to the heap of ashes ; and the Ocean to the water of the bason ; and insist that the water of Springs rises in the same manner through hills and mountains.—I am not informed, that any experiments have been tried to ascertain the height, to which water will thus ascend through ashes, or through sand. The cause of its ascent, however, is well known to be a mutual attraction subsisting between the particles of ashes or sand, and those of water. Whether this attraction be chemical or mechanical, it is to me self evident, that no attraction can *raise* more water than it can *sustain*.—If it is *chemical*, it will continue to raise the fluid until the heap is thoroughly *saturated*, and no longer. Should the other particles of the fluid attempt to supplant those which were first combined, these would effectually resist the attempt by the right of *oc-*

cupancy. If the attraction is merely *mechanical*, its force is well known to diminiſh, *as the ſquare of the diſtance increaſes.* The heap, therefore, being ſuppoſed to have raiſed as much water as it can ſuſtain; it is obvious, that the particles of water actually raiſed will be in immediate contact with the aſhes or ſand; while all the other particles will be at a greater diſtance from it. The water *raiſed* will thus be more ſtrongly attracted, than the water *not raiſed.* Of courſe, the aſhes or ſand will continue to ſuſtain the particles firſt raiſed: and will not be compelled, by a weaker force, to let them go, and thus make room for others. In other words, a feebler attraction can not overcome one that is more powerful.

But it is ſaid, that if we conceive of angular pipes or ducts in the Earth, having the form, poſition, and properties, of a *ſyphon;* the water of the Ocean may aſcend and be diſcharged through them, by the ſame laws which regulate that inſtrument. We will admit, for the argument, that it is ſtrictly philoſophical to conceive of ducts or pipes in the Earth *hermetically tight*, and of a ſufficient extent to anſwer the purpoſe. This hypotheſis will, nevertheleſs, be attended with an inſuperable difficulty. It is well known, that the diſcharging oriſice of the ſyphon muſt be horizontally lower than the ſurface of the reſervoir. In the caſe ſuppoſed the Ocean is the reſervoir. Of courſe, no ſpring, that is not ſomewhat below the level of the Ocean, can be ſupplied by a natural ſyphon. With the few ſprings ſo ſituated, we will not embarraſs our enquiries: ſatiſfied, that that WISDOM, which operates by general laws; and, by the ſimpleſt means, produces the moſt magnificent reſults; when it had filled the "*Upper Springs*, could find no difficulty in ſupplying the "*nether.*"

The *Wet Rag*, like the Syphon, has been called in to relieve the perplexities of Philoſophy. It is well known, that if ſuch a rag is thrown partly over the ſide of a veſſel of water, the water will drop from the exterior end of the rag, until the whole is thus drawn off. The

Wet Rag in this case is a sort of clumsy natural syphon. But, like the more regular instruments of art, it is faithfully true to its principles of action. Unless the surface of the fluid is above the horizontal level of the exterior end of the Rag, it is found, that not a drop of water will fall.

None of these various schemes, therefore, if they would explain the ascent of water to the orifices of springs, will account for its running over.

Nor will either of them furnish the reason, why the water of springs is fresh. The water, when it begins to ascend, is mere brine; and is supposed to lose its salt in the passage. If it were true, that brine would thus become fresh, it would follow, that the lowest stratum of earth, or that nearest the Ocean, would be immediately, and the superior strata gradually, saturated with salt; and both would of course decline receiving any more from the brine, as it passed them on its way upward to the fountains. The brine would thus freshen less and less in its passage; and in the end would continue wholly salt. The lower strata, also, would soon be saturated with solid salt; that either the tubes, or the interstices, or the syphons, would become completely clogged, and incapable of any farther transmission of brine.

But it is not true, that sea-water is made fresh, by filtering through dry sand or dry earth. Experiment has proved, again and again, that, if brine is filtered through dry earth any number of times, its saltness is not perceptibly diminished. The quantity of fluid is indeed lessened; but that, which remains at the end of the process, is found to retain its original proportion of salt; and that, which is retained by the sand, adheres to it in the shape of *brine*, and not of *solid salt*. These considerations have satisfied me, that we must look to some other source than the Ocean, for the water of Springs.

The second class of Theories comprises those, which attribute the Origin of Springs to a vast Abyss in the bowels of the Earth.

When Philoſophy diſcovered this Abyſs, her *motives* were praiſe-worthy, whatever we may think of her *Logick.* Infidelity had often attacked the Scriptural account of the Deluge, on the ground, that all the water on the globe was not ſufficient to cover its ſurface to the depth repreſented by MOSES. This objection, if the fact it aſſerts were true, would reſt on the unfounded principle, that the CREATOR of all things is dependent on *the things that are made* for the accompliſhment of his purpoſes. Some well meaning friends of the Penteatuch, alarmed for the credit of MOSES, deviſed this Abyſs as the receptacle, in which the waters of the Deluge were gathered, *that they might no more overflow the face of the Earth.* Several philoſophers, who had been put to great difficulty to account for the Origin of Springs, finding, in their ſubterranean reſearches, ſo copious a reſervoir prepared to their hands ; immediately ſeized upon it as the ſource, whence they were ſupplied with water.

The beſt account I have ſeen of this Abyſs, and of the manner in which fountains are fed by it, is found in CATCOTT'S *Treatiſe on the Deluge :* a work declared by JONES and ADAMS, two diſtinguiſhed philoſophers of Great Britain, one of the laſt, the other of the preſent century, to be " the moſt critical and ſatisfactory diſcourſe extant on the origin of Springs and Rivers."

Mr. CATCOTT explains his own view of the internal ſtructure of the Earth, as it has exiſted ſince the Deluge, by an engraving, repreſenting *the plane of one of its Great Circles.* " At the centre we find," to uſe his own language, " a ſolid ball, or *Nucleus*, of terreſtrial matter, formed from what the water of the Deluge, in its deſcent from the ſurface and paſſage through the ſtrata of the Earth, tore off, and carried down with it into the Abyſs, and repoſited at the loweſt place. Around this Nucleus is the great *Abyſs* of water, with which all ſeas, lakes and rivers communicate. This Abyſs contains ſo large a quantity of water, that only a ſmall part of it was uſed at the Deluge. Laſtly, we find the *Crust* of the Earth surrounding the Abyss, and broken into innumerable apertures and fissures; the largest of which are the beds of Lakes, Seas and Oceans; the next less are the canals for the waters of Springs; and the least, the cracks, through which the vapours of the Abyss ascend into the Atmosphere." To render this account more intelligible the Author compares the Earth to an *Egg*: its *Crust* to the *Shell*; the *Abyss*, to the *White*; and the *Nucleus*, to the *Yolk*. He then enters into an elaborate argument to prove the existence of this Abyss of waters; an attempt, in which he is pronounced successful by JONES and ADAMS.

Three methods are pointed out by Mr. CATCOTT, in which the waters of the Abyss may be conveyed to the orifices of Fountains:

By the ascent of Vapour through the Cracks in the Crust;

By Upward Filtration; and

By the Pressure of the Ocean.

The Vapour, mentioned in the first method, is supposed to be occasioned by a *fire*, existing somewhere in the bowels of the Earth. To avoid repeating what has already been said respecting an internal fire; I will barely remark, that such a fire can not exist in the *Nucleus*; for there can be no regular supply of air to support it: nor in the *Abyss*; for, had it once been kindled there, the water must immediately have extinguished it: and that if supposed to exist in the *Crust*, it could have no effect on the waters beneath. Were we, however, to allow the existence of such a fire in the *Nucleus*, operating on the bottom of the Abyss, like our common culinary fires on the bottom of a kittle: still, the Vapour thus occasioned would be condensed, in its ascent through many miles of cold water, long before it reached the under surface of the Crust. The only alternative is to imagine the Abyss to be, and to have always been, an immense subterranean ocean of *hot water*.—In this way, if we suppose 1st. That there is such an abyss; 2dly. That it is a mere mass of hot water; 3dly. That the Cruſt of the Earth has the requiſite number of cracks and fiſſures; and 4thly. That, near the ſurface, the vapour finds the proper caverns or refrigeratories to condenſe in: we ſhall have made but two more ſuppoſitions than the Indian, who put the Earth on an Elephant, and the Elephant on a Tortoiſe.

If Vapour is thus continually riſing from the Abyſs, why do we never ſee it making its way above the ſurface in a viſible ſhape? To this queſtion, Mr. CATCOTT replies, " As to the aſcent of Vapour through the fiſſures of the Earth, this is a fact, the reality of which any one may be convinced of, who will give himſelf the trouble *of looking into the inſide of the Earth.*" Of the Earth, moſt of us, probably, are merely ſuperficial obſervers. For myſelf, unfortunately, I never had an opportunity of examining its *inſide* except while exploring a cave about 70 feet deep. In that, and in moſt other caverns and mines, water is ſeen dropping from the roof, and trickling down the ſides, of thoſe ſubterranean receſſes; and the atmoſphere, thus continually moiſtened, has no chance of being dried by the heat of the Sun. Miners, however, and moſt other viſiters of caverns, guided by common ſenſe, have been led to attribute the moiſture to theſe cauſes, and not to ſubterranean exhalations.

The ſecond method deviſed for the aſcent of the waters of the Abyſs is Upward Filtration. I flatter myſelf, that it has been already evinced—that water cannot, thus, aſcend to a ſufficient height:—That, if it could, it would not run over; and that, ſuppoſing it would run over, yet, if originally ſalt, it could not be made freſh.

With regard to the quality of the water of the Abyſs, Mr. CATCOTT obſerves, that " we cannot have any abſolute proof that it is ſalt; and I could give ſeveral reaſons to ſhow that it may not be ſo; at leaſt, not equally ſalt with the ſea." What theſe reaſons are he does not inform us. Perhaps it is owing to this omiſſion, that ſeveral reaſons of a contrary efficacy have ſatisfied me, that the Abyſs, even if it were originally freſh, muſt now conſiſt of ſalt water. The Deluge prevailed on the Earth *one hundred and fifty* days. The waters of the Abyſs, according to Mr. C. were employed, as ſubſidiary to thoſe of the Ocean, in drowning the *dry land;* and then were returned *to their appointed bed.* Great indeed muſt have been the care, taken during that long period, to prevent the brine of the Ocean from intermixing with the freſh water of the Abyſs.

The Ocean, alſo, according to Mr C. communicates directly with the waters of the Abyſs; or in other words, is a part or continuation of it. If this be the caſe, the waters of the Abyſs muſt be at leaſt as ſalt as thoſe of the Ocean; for ſalt water is heavier than freſh, and will ſink in it until there is produced an equilibrium of ſpecific gravity.

If the Ocean is not a part of the Abyſs, but reſts upon a ſubſtratum of earth, which in its turn reſts upon the ſurface of the Abyſs; then, no reaſon can be aſſigned why a due proportion of the cracks and fiſſures in the cruſt ſhould not be aſſigned to the bed of the Ocean. Only one fifth of the ſurface of the globe is dry land. The remaining four fifths are covered by the Sea. The Dry Land, according to the hypotheſis, has as many ſuch fiſſures as it has Springs. And ſingular indeed muſt have been the care neceſſary after the Deluge, in ſettling the Wreck of Elements, to diſtribute these fiſſures in ſuch a manner, that ſo many ſhould be found in the Land, and not one in the bottom of the Ocean.

If theſe cracks and fiſſures are impartially diſtributed over the Cruſt of the Earth; it is clear, that the waters beneath muſt be as ſalt as thoſe above. Let us ſuppoſe that, during the Deluge, the waters of the Abyſs, by a ſtrange coyneſs, were preſerved from contamination; and that, after their *briny ordeal*, they returned *pure* to their native bed. Still they could only have returned to meet dangers inſurmountable. The brine of the Ocean, being ſpecifically heavier, muſt immediately have begun to deſcend through ſome of the cracks, and the water of the Abyſs to aſcend through others. Nor could the proceſs have ceaſed, until it had produced an equilibrium of preſſure. If this rotation in the waters of our Great Globe is not yet over, it will account, in a manner which HALLEY never dreamed of, for whirlpools, edies, and waterſpouts.

The third mode contrived for the aſcent of the water of the Abyſs is the preſſure of the Ocean. This Preſſure is thus explained.—A crack or fiſſure paſſes downward, from the orifice of every ſpring, through the Cruſt, to the ſurface of the Abyſs, which is ſuppoſed to be freſh. If water is poured into one arm of a bended tube, and oil into the other; the level of the oil, as being the lighter fluid, will remain higher than that of the water. The whole cavity of the Ocean may be conſidered as one arm of ſuch a tube; a given crack or fiſſure, the other; and the Abyſs, the connection between them. The brine of the Ocean, preſſing upon the lighter fluid of the Abyſs, will force it up through the fiſſure, to a greater height than its own level, and thus will form a ſpring.

On this ſcheme, the Ocean muſt be *connected* with the Abyſs; for, if it *is not*, it cannot preſs upon it. If it *is* connected with it, then I think it has been proved, that the waters of the latter muſt be ſalt. If they are ſalt, the preſſure of the Ocean cannot raiſe them above its own level; for, if water alone is poured into a bended tube, one arm of which is a hundred or a thouſand times as large as the other, ſtill the ſurface of the fluid in both will have the ſame horizontal level.

But if this preſſure *would* raiſe the waters of the Abyſs to a ſufficient height; ſtill, it would not make them freſh. The cracks or fiſſures are mere tubes of a *palpable* diameter; and to freſhen brine, merely by paſſing it through a tube, is a harder problem than a diſcreet Chemiſt would attempt to ſolve.

The manner in which ſprings iſſue from the ground, alſo, completely diſproves the theory. Springs make their way nearly to the tops of the Andes. If the preſſure of the Ocean is ſufficient to force the water of the Abyſs to ſuch a height; but little of its force can have been ſpent in ſuch ſprings as iſſue on plains. In theſe, therefore, the water, inſtead of merely gurgling upwards, as they actually do, ſhould riſe in *jets;* and contiue riſing, until the impulſe communicated by this preſſure was overcome by the reſiſtance of the air, and the Force of Gravity.

As to the length of the cracks or fiſſures connecting Springs with the Abyſs, it ſhould be remarked that the *Cruſt* or *Shell* of the Earth cannot, on any reaſonable ſuppoſition, be conſidered as leſs than ſeveral miles in thickneſs. In a Globe of 8000 miles diameter, with a centrifugal force at its equator ſo powerful as that of the Earth; it will be readily *felt* by every man, that unleſs the Cruſt were ſolid and ſubſtantial, there would be conſtant and imminent hazard of ſomething worſe than a mere *fiſſure.* Springs, alſo, are often two or three miles above the level of the Ocean. Each Spring muſt have its own fiſſure commencing at the ſurface of the Abyſs, and reaching through the Cruſt to the orifice. The man, who can believe that the SUPREME BEING could deviſe no eaſier and better mode of watering the Earth, muſt I think, be in great danger of *thinking him,* ſo far as his wiſdom is concerned, *altogether ſuch an one as himſelf.*

Leaving, then, our ſubterranean reſearches, we will examine the Theory, which diſcovers the Origin of Springs in Vapour.

Vapour, as here uſed, is a comprehenſive term, including all the water, that riſes from the ſurface of the Earth by evaporation; and all, that deſcends on it in the form of dew, fog, miſt, rain, ſnow, and hail.

This Theory may be thus explained. The Ocean is conſtantly loſing vaſt quantities of water by evaporation. Electrified bodies attract light ſubſtances floating near them. The Land is more highly electrified than the

Ocean. Moſt of the vapour thus raiſed is drawn from the ſea to the land. As mountains are more highly electrified than plains, they attract the great body of the vapour which retains the form of miſt; while of that, which deſcends in a more ſolid form, much more falls on the former than on the latter. The miſt on mountains condenſes, and is precipitated in water. This united with the water of rain and ſnow, penetrates the ſtrata of ſand and the lighter earth, till it is ſtopped in its courſe by more impervious ſubſtances; particularly ſtrata of clay. In theſe, it forms a baſon or reſervoir; from which, gradually working a paſſage, it iſſues out of the ſide of the hill, in the form of a Spring.

Dr. Halley was the inventor of this Theory. His attention was directed to the ſubject by the following fact. While buſied in making ſome celeſtial obſervations, on a hill in the iſland of St. Helena, he found, even when the ſky was perfectly clear, that the quantity of vapour collected on his lenſes, every few minutes, was ſo great, as wholly to impede his viſion.

The following well-known facts may be adduced in its ſupport.

Water, in the form of Vapour, is conſtantly riſing from the Sea, in very large quantities, and in a ſtate of freſhneſs.

Rains are far more frequent and copious on mountains, than on plains; and in mountainous countries, than thoſe that are level.

The earth on mountains is always moiſt; even during a drought.

Almoſt all ſprings iſſue out of the ſides of hills or mountains, or from lands adjoining them.

The loftieſt mountains yield the moſt numerous rivers; and the largeſt, alſo, where they are far enough from the ſea.

Brooks are uncommon in champagne countries; and in countries, which have a ſtiff clay on the ſurface.

Brooks and Rivers may univerſally be traced to hills or mountains.

Streams, wells, and fountains are fulleſt in the Spring. In the Autum, many of them are abſolutely dried up.

Theſe facts collectively prove, that the quantity of water depoſited on mountains is very great ; that they are well qualified to retain it for the ſupply of Springs ; and that ſprings and rivers are all of them in part, and many of them wholly, ſupplied from this ſource.

Various objections are urged againſt this theory. The firſt is that water will not ſoak far enough into the ground. M. De La Hire, a French Philoſopher, to prove this, tried the following experiment. He dug a hole in the lower terrace of the Obſervatory at Paris ; and placed therein, eight feet under ground, a large leaden baſon, inclined a little towards one of its angles. To this was ſoldered a pipe, 12 feet long ; which, after a conſiderable deſcent, reached into an adjoining cellar. He then filled up the hole with a mixture of ſand and loam. After having kept the baſon, in this ſituation, 15 years, (the ground being conſtantly expoſed to all the rains and ſnows that fell,) he could never obſerve that a ſingle drop of water had paſſed through the pipe into the baſon.

On this ſubject, I will make two remarks. 1st. Water will certainly filter *down*, as eaſily as it will filter *up* ; The attraction between the ſand and the water is in each caſe the ſame ; and in filtering down, it has the very ſerious aſſiſtance of Gravity. If then, it will filter upwards many miles, it will certainly filter downwards eight feet. 2dly. Our own eyes teach us, that deep wells frequently fail in dry weather ; and that wells which are 30 or 40 feet deep are often very obviouſly raiſed by the hard rain of a ſingle night. Hence I am led to conclude, either that the pipe employed in the experiment became clogged ; or that Providence knows how to arrange earth, for the paſſage of water through it, better than M. De La Hire.

It is likewiſe objected that ſprings often riſe on plains, and ſometimes on the ſummits of hills. Such occurrences are uncommon. Of the few Springs which I have heard of as rifing on the tops of hills, almoft all have been found, on examination, to iflue many feet below the real apex. Were the fact otherwife, it would not be inconfiftent with the Theory.—In ftiff clayed grounds water may work its way a very confiderable diftance, before it finds an outlet. Springs, in wet lands, fhould be expected often to iffue feveral miles from the refervoir. "And," in the language of Hutton, "if there happen to be a valley, between a mountain on whofe top is a fpring and the mountain which is to furnifh it with water; the Spring muft be confidered as water conducted from a refervoir of a certain height, through a fubterranean channel, to make a jet of an almoft equal height."

It is alfo faid, that fome fprings are not at all affected by drought. This may be owing to the capacity of the reservoir; and to the number of ducts which fupply it, and to the fmallnefs of the drain.

But the principal objection is the infufficiency of vapour to fupply the demands of fprings and rivers.

DR. HALLEY tried the following experiment, to determine the actual evaporation from the Mediterranean, so far as it is occafioned by heat. He filled a bafon with brine, as falt as that of the Ocean; and heated it, over a pan of coals, to the temperature of the air in fummer. By a careful examination he found, that the quantity loft by evaporation was a tenth of an inch in 12 hours. He fuppofes the Mediterranean to be 40° long, and 4° broad; making a furface of 160 fquare degrees. According to the experiment, therefore, it will lofe 5,280,000,000 tons of water in a day. The Mediterranean receives the waters of the following confiderable rivers; the Ebro, the Rhone, the Tyber, the Po, the Danube, the Neifter, the Neiper, the Don, and the Nile. DR. HALLEY fuppofed, that, on an average, each of thefe yields ten times as much water as the Thames; whereby he allowed for fmaller rivers which fall into the fame fea. From an ingenious menfuration, he concluded, that the Thames difcharges daily 20,300,000 tons.

The nine rivers, therefore, difcharge into the Mediterranean 1,827,000,000 tons of water in a day; which is but little more than a third of what is raifed from its surface in the fame time, by evaporation.

The above eftimate of the water of the Thames is profeffedly overrated, and has fince been found, by MR. DALTON the Philofopher of Manchefter, to be about one third two large. Reducing the nine rivers in this proportion, we fhall find that their daily difcharge is only 1,218,000,000 tons This is rather lefs than 1–4th of the quantity evaporated from that sea; and leaves 4,062,000,000 tons, or 3–4ths of the whole, to meet the evaporation from that immenfe region, by which thefe rivers and their branches are fupplied.

From a feries of obfervations refpecting the annual fupply of rain, made at 31 different ftations in England, during different periods of from 1 to 21 years, MR. DALTON finds the average quantity for the whole of England and Wales to be 31 inches. To this he adds 5 inches for dew; making a total of 36 inches or three feet. After a minute examination of the rivers of thofe two countries, he eftimates their whole annual discharge to be nine times that of the Thames. Allowing this calculation to be correct, the rivers will exhauft only 13 inches of rain; leaving 23 inches to evaporate from the land: a refiduum, which he finds, by a number of experiments, to be amply fufficient.

The quantity of rain, which falls in our own country, is believed to be confiderably greater than that in any country of Europe. The exact amount however cannot, at prefent, be ftated with precifion; as few gentlemen have hitherto made the requifite obfervations. I can only obferve, that I have feen various regifters of rain kept at different places for confiderable periods: and the average refults of a ftill larger number. From thefe I am led to conclude, that the quantity of water, which annually falls in rain fnow and hail, will average 45 inches. To this fhould be added 5 inches, at leaft, for dew; making the whole 50 inches. The United

States comprife a million of fquare miles. Thirty five cubic feet of rain water weigh a ton. A mafs of water, covering 1,000,000 fquare miles to the depth of 4 feet 2 inches, contains 116,160,000,000,000 cubic feet; amounting to 3,318,860,000,000 tons.

By an examination of the Map of the United States it will appear, that, on its borders and within it, there are 26 great *primary* rivers, or rivers communicating directly with the Ocean. Thefe are the St. Lawrence, Penobfcot, Kennebec, Ameriscoggin, Saco, Merrimac, Connecticut, Hudfon, Delaware, and Sufquehannah, in the North; and the Potowmac, Rappahanoc, York, James, Roanoke, Pamlico, Neufe, Cape Fear, Pedee, Santee, Savannah, Ogeechee, Altamaha, Apalachicola, Mobille, and Miffiffippi in the South. The St. Lawrence receives half of its water from the Canadas; and more than three fourths of the fupplies of the Miffiffippi are furnifhed by Louifiana. Of this the proof is direct. The *Ohio*, the only very large tributary from the eaft, is fmaller than the *Arkansas*; and the *Illinois*, the only remaining eaftern branch worthy of notice, is much lefs than the *St. Francis*. On the Weft, however there are alfo the *Miffouri*, which is larger than the Miffiffippi itfelf before the junction, added to all the branches from the eaft; and *Red River*, which is much larger than the Ohio.

Of the remaining *primary* rivers, the Amerifcoggin, Saco, Merrimac, Rappahannoc, York, Pamlico, Neufe, and Cape Fear, are about as large as the Thames; and the Penobfcot, Kennebec, Ogeechee, and Altamaha, are not much larger. Taking thefe facts into confideration, I am fatisfied, that, if we admit each of the 26 primary rivers to yield ten times as much water as the Thames, we fhall allow a fufficient overplus to fupply all the primary ftreamlets. On this fuppofition the annual difcharge of water from all the rivers of the Union will amount to 1,281,660,000,000 tons: leaving a refiduum of 2,037,200,000,000 tons to fupply the demands of evaporation from the land.

I am aware, that such calculations, in their own nature, do not admit of that certainty which is demanded in demonstration. Still they are sufficiently accurate to leave the mind satisfied. I am also aware, that their want of certainty comes with an ill grace from the mouth of the objector. As the advocates of the theory prove, in the outset, that many springs are wholly supplied in this manner; the case with respect to the others, is *prima facie* with them. As the objector takes the issue, the burden of proof rests upon his shoulders. Until it is actually furnished I believe we shall all admit, that Springs owe their origin only to Vapour.

No. XX.

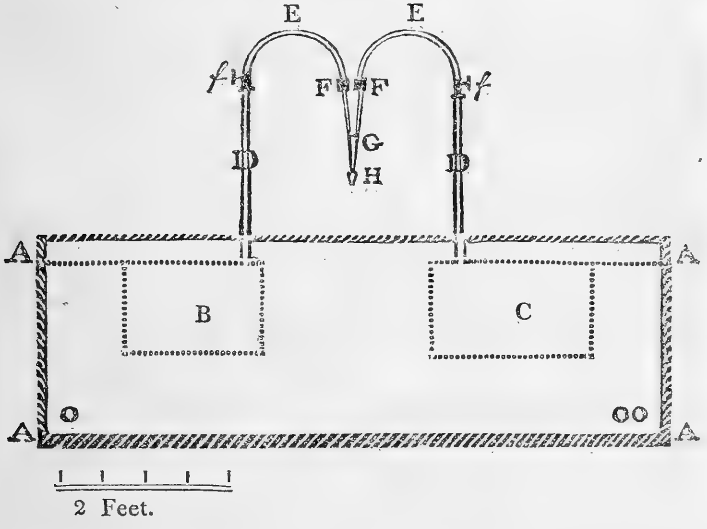
EXPERIMENTS

On the Fusion of various refractory Bodies, by the

COMPOUND BLOW-PIPE OF MR. **HARE,**

BY BENJAMIN SILLIMAN, PROF. CHEM. AND MIN. IN YALE-COLLEGE.

A SECTION OF THE **PNEUMATIC CISTERN** OF YALE COLLEGE WITH THE **COMPOUND BLOW PIPE** OF MR. HARE FOR BURNING HIDROGEN, MINGLED WITH OXIGEN GAS.



REFERENCES TO THE FIGURE.

AAAA.—The pneumatic cistern, filled with water; for a plate, and full description, see the Boston Edition of Henry's Chemistry.

B.—A Gas Reservoir, of the capacity of twelve gallons, filled with oxigen gas, either by the action of the hydrostatic bellows at O, or, by a recurved tube, passing from above, through the water, and hooked under B: parallel, and contiguous to B, on the other side of the cistern, is another gas reservoir, of the same capacity, which may be connected with B, or not, at pleasure.

C.—The same, in every respect, only C is filled with hidrogen, by hydrostatic bellows at OO, or by a recurved tube, as above.

D.—Copper Tubes, half an inch in diameter, furnished with stop cocks at *f*, and inserted into the gas reservoirs B. C.

E.—Recurved tubes of flexible metal, furnished with double screws at F, which connect them with a pair of brass blow pipes, cut off at G, and soldered to two strong cast silver tubes, which screw, *air tight*, into H, an inverted pyramidal piece of platinum, in which, two converging ducts as large as a pin are perforated, forming a continuation of the tubes, and uniting in a common passage, somewhat larger, just before their exit, at the common orifice below. The subject to be operated upon is sustained by charcoal, or forceps, and held by the hand, just below the orifice in the piece H.

The gasses at B. C are under hydrostatic pressure, which is easily recruited, as the gasses run out, either by throwing common air with the bellows, into one of the spare reservoirs, or, by introducing more of either of the gasses into the appropriate reservoir, and, peculiarly of hidrogen, both, on account of the facility with which it is obtained, and because, twice as much of it, in bulk, is wanted, as of oxigen.

The rapidity of efflux of the gasses, and their due proportion, is easily regulated, by turning, more or less, the keys of the stop cocks at *f*, and the effects of either gas alone, may be observed, by shutting the stop cock leading to the other.

When the compound flame is desired, the hidrogen is first let out, and fired ; the blaze should be somewhat larger than that of a candle ; the oxigen is then let into the hidrogen till the effect is the greatest, which a little habit will soon ascertain.

The flame of the hidrogen is very much narrowed, by the introduction of oxigen, and there is no appearance of peculiar splendor or heat, till some body, capable of reflecting the light and heat, is placed in the focus, which is usually about one fourth of an inch below the orifice.

All the apparatus below F F is easily detached, by turning the double screws ;—the strong silver tubes are intended to prevent fusion of this part of the apparatus, and to admit of connexion with the platinum piece by *means of a screw cut on the silver tubes ;* this obviates the necessity of using a solder, which would be very liable to melt, and, the platinum piece is, for a similar reason, substituted for the silver cylinder originally used by Mr. Hare, as experience has shewn that these are liable to fusion.

No flux or addition of any kind was employed in the following experiments.

EXPERIMENTS

ON THE FUSION OF VARIOUS REFRACTORY BODIES BY THE COMPOUND BLOW-PIPE OF MR. HARE.

THE philoſophical world behold with pleaſure and aſtoniſhment, the effects produced on the fuſion and combuſtion of bodies, by a stream of oxygen gas, directed upon burning charcoal. The ſplendor of these experiments arreſted univerſal attention, and Lavoisier, with his gazometer, was enabled, in this manner, to produce a degree of heat, ſurpaſſing that of the moſt powerful furnaces, and even of the ſolar focus. Bodies which no degree of heat, previously applied, had been able to ſoften, now became fluid, and philoſophy appeared to have attained the limit of its power in exciting heat; indeed, it ſeemed to have advanced, very far, towards realizing the opinion, that ſolidity and fluidity are accidental attributes of bodies, dependant ſolely on the quantity of caloric which they contain, and that therefore, they may be ſuppoſed capable of exiſting in either of theſe conditions.

Still however, there were, *in fact*, many important exceptions. Of the primitive earths, Lavoisier had been enabled to fuſe only alumine—while the reſt remained refractory, and ſeemed fully entitled to the character of infuſibility, uſually attributed to this claſs of bodies: many native minerals and eſpecially thoſe which are moſt diſtinguiſhed for hardneſs, beauty, and ſimplicity of compoſition, maintained the ſame character, and ſome of them refuſed to melt even when heated with powerful fluxes.

The beautiful invention of Mr Robert Hare of Philadelphia, by which he ſucceeded in burning, with ſafety and convenience, the united ſtream of oxygen and hidrogen gases, greatly extended our dominion over refractory bodies, and preſented new and very intereſting reſults. Mr. Hare's memoir, originally communicated to the Chemical Society of Philadelphia, has been fome years, before the public, and has been republifhed and handfomely noticed, both in France and England. Still however, his refults have not found their way into the Syftematical books on Chemiftry, (with the exception of Mr. Murrays system,) notwithftanding that fome of the European Profeffors have availed themfelves of Mr. Hare's invention, fo far as to exhibit his moft fplendid and ftriking experiments to their claffes.

The writer of this article, although fully difclaiming any share in Mr. Hare's invention, was early affociated with him in his experiments; they excited in his mind a degree of intereft, which led him to hope that they would be repeated and extended by others, but, as nothing of this kind has appeared in this country, perhaps the following experiments may not be altogether uninterefting, especially as they were performed with an apparatus, of a conftruction fomewhat more fimple than the original.

It will be neceffary to recollect that Mr. Hare not only melted alumine, which Lavoifier had done before, but alfo *silex and barytes*, and, by fubfequent experiments, he added *strontites*, to the lift of fufible bodies: he was inclined to believe that he had volatilized gold and filver, a conclusion which was rendered highly propable by his having afterwards evidently volatilized platinum.

The experiments of Mr. Hare, as will appear below, have been repeated by the writer of this paper with fuccefs, and many other bodies among the moft refractory in nature, have been melted. For the fake of fhewing how far the experiments now to be recited have affected our knowledge of the dominion of heat, quotations, for comparifon, will occafionally be made, from one of the lateft and moft refpectable chemical authorities.

(Murray's System 2d Ed.)

BODIES SUBMITTED TO THE HEAT OF THE COMPOUND BLOW-PIPE OF MR. HARE.

PRIMITIVE EARTHS.

SILEX—being in a fine powder, it was blown away by the current of gas, but when moiftened with water, it became agglutinated by the heat, and was then perfectly fuſed into a colourleſs glaſs.

Alumine—perfectly fuſed, into a milk white enamel.

Barytes—fuſed immediately, with intumeſcence, owing to water, as obſerved by Lavoiſier; it then became ſolid and dry, but ſoon melted again into a perfect globule, a greyiſh white enamel.

Strontites—the same.

Glucine perfectly fuſed into a white enamel.

Zircon—the ſame.

Lime–in ſmall pieces, it was immediately blown off from the charcoal; to prevent this, as well as to obviate the suspicion, that any foreign matter had contributed to its fuſion, the following expedient was reſorted to. A piece of lime, from the Carrara marble, was ſtrongly ignited, in a covered platinum crucible; one angle of it was then ſhaped into a ſmall cylinder, about one fourth of an inch high, and ſomewhat thicker than a great pin: the cylinder remained in connection with the piece of lime: this was held by a pair of forceps, and thus the ſmall cylinder of lime was brought into contact with the heat, without danger of being blown away, and without a poſſibility of contamination; there was this farther advantage, (as the experiment was delicate and the determination of the reſult might be difficult,) that, as the cylinder was held in a perpendicular poſition, if the lime did really melt, the column muſt ſink and become, at leaſt to a degree, blended with the ſupporting maſs of lime. When the compound flame fell upon the lime, the ſplendor of the light was perfectly inſupportable, by the naked eye, and when viewed through deep coloured glaſſes (as indeed all theſe experiments ought to be,) the lime was seen to become rounded at the angles, and gradually to sink, 'till, in the courſe of a few ſeconds, only a ſmall globular protuberance remained, and the maſs of ſupporting lime was alſo ſuperficially fuſed at the baſe of the column, through a ſpace of half an inch in diam-

D

eter. The protuberance, as well as the contiguous portion of lime, was converted into a perfectly white and gliſtening enamel; a magnifying glaſs diſcovered a few minute pores, but not the ſlighteſt earthy appearance. This experiment was repeated ſeveral times, and with uniform ſucceſs; may not lime therefore be added to the liſt of fuſible bodies?

MAGNESIA.—The ſame circumſtances that rendered the operating upon lime difficult, exiſted, in a ſtill greater degree, with reſpect to magneſia; its lightneſs and pulverulent form rendered it impoſſible to confine it for a moment upon the charcoal, and as it has very little coheſion, it could not be ſhaped by the knife as the lime had been. After being calcined, at full ignition, in a covered platinum crucible, it was kneaded with water, 'till it became of the conſiſtence of dough. It was then ſhaped into a rude cone as acute as might be, but ſtill very blunt; the cone was three fourths of an inch long, and was supported upon a coiled wire.

The magneſia, thus prepared, was expoſed to the compound flame: the eſcape of the water cauſed the vertex of the cone to fly off in repeated flakes, and the top of the fruſtrum, that thus remained gave nearly as powerful a reflection of light as the lime had done; from the bulk of the piece (it being now one fourth of an inch in diameter at the part where the flame was applied) no perceptible ſinking could be expected. After a few ſeconds, the piece being examined, with a magnifying glaſs, no roughneſſes or earthy particles could be perceived on the ſpot, but a number of glaſſy, ſmooth protuberances, whoſe ſurface was a perfectly white enamel; this experiment was repeated with the ſame ſucceſs. May not magneſia, then, be alſo added to the table of fuſible bodies?

YTTRIA—was the only remaining primitive earth, but no ſpecimen of it could be obtained.

Perhaps then we ſhall be juſtified in ſaying, in future, that the primitive earths are fuſible bodies, although not fuſible in furnaces, in the ſolar focus, nor, (with the exception of alumine, and poſſibly, barytes,) even by a ſtream of oxygen gas directed upon burning charcoal.

PLATINUM—was not only melted but volatized with ſtrong ebullition.

VARIOUS MINERALS.

ROCK CRYSTAL,—tranſparent and colourleſs. This mineral was inſtantly melted into a beautiful white glaſs. " It not only does not melt in the focus of the moſt powerful burning mirror, but, it remains without fuſion, at leaſt when in the ſtate of Rock Cryſtal, in the ſtill more intenſe heat, excited by a ſtream of oxigen gas directed on burning charcoal." (Murray II. 261.) " It is even imperfectly ſoftened by the intenſe heat, excited by a ſtream of oxigen gas, directed on the flame." (of the blow pipe lamp.) —(Ibid III. 513.)

COMMON QUARTZ—fuſed immediately into a vitreous globule.

GUN FLINT–melted with equal rapidity; it firſt became white, and the fuſion was attended with ebullition and a ſeparation of numerous ſmall ignited globules which ſeemed to burn away as they rolled out of the current of flame; the product of this fuſion was a beautiful ſplendid enamel.—" It is infuſible before the blow pipe but loſes its colour."—(Ibid. 518.)

CHALCEDONY—melted rapidly, and gave a beautiful bluiſh white enamel reſembling opal. " It is infuſible before the blow pipe."—(Ibid. 516.)

ORIENTAL CARNELIAN—fuſed with ebullition, and produced a ſemitransparent white globule with a fine luſtre.

RED JASPER—from the Grampians, was ſlowly fuſed with a ſluggiſh effervеſcence, it gave a greyiſh black ſlag, with white ſpots.

"It is infuſible before the blow pipe, even when the flame is excited by a ſtream of oxygen gas." (Ibid. 519.)

SMOKY QUARTZ—or ſmoky topaz melted into a colourleſs globule.

BERYL—melted inſtantly, into a perfect globule, and continued in a violent ebullition, as long as the flame was applied, and when, after the globule became cold, it was heated again, the ebullition was equally renewed; the globule was a glaſs of a beautiful blueiſh milky white.

"The beryl is melted with difficulty before the blow-pipe alone, but eaſily when borax is added."

EMERALD of PERU. (Ibid 511.)

The ſame, only the globule was green, and perfectly tranſparent.

OLIVIN—fuſed into a dark brown globule, almoſt black.

"It can ſcarcely be melted by the blow pipe without addition." (Ibid 534.)

VESUVIAN—inſtantly melted into a beautiful green glaſs.

"It melts before the blow pipe into a yellowiſh glaſs." (Ibid 534.)

LEUCITE—inſtantly fuſed into a perfectly tranſparent white glaſs; the fuſion was attended with ſtrong ebullition, and many ignited globules darted from it and burnt in the air, or rolled out upon the charcoal and then burned. Were they not potaſſium? This ſtone contains full 20 per cent of potaſh: this hint will be reſumed below.

"It is not fuſed before the blow pipe." (Murray III. 534.)

CHRYSOBERYL—(Cymophane of Hauy) was immediately fuſed into a greyiſh white globule. "It is not melted by the blow pipe," (Ibid 499.)

A CHRYSTALIZED MINERAL.

From Haddam, Connecticut, according to the Abbe Hauy it is Chrysoberyl, according to Col. Gibbs, Corundum: it fuſed with ebullition, and ſcintillations, and produced a very dark globule almoſt black.

TOPAZ—of SAXONY, melted with ſtrong ebullition, and became a white enamel. " It is infuſible before the blow pipe, but melts when borax is added." (Ibid 498.)

SAPPAR or Kyanite—perfectly and inſtantly fuſed, with ebullition, into a white enamel.

" It remains perfectly unaltered before the flame of the blow pipe even when excited by oxygen gas." (Ibid 499.)

CORUNDUM—of the Eaſt Indies, was immediately and perfectly fuſed, into a grey globule.

CORUNDUM—of China, the ſame with active ebullition. Corundum " is not fuſed by the flame of the blow-pipe on charcoal even when ſoda or borax is added to it." (Ibid 495.)

ZIRCON—of Ceylon melted, with ebullition, into a white enamel. " It is not melted alone before the flame of the blow pipe, but if borax is added it forms a transparent glaſs." (Murray III. 539.)

HYACINTH—of Expailly fuſed into a white enamel.

" It loſes its colour before the flame of the blow-pipe, but it is not fuſed; it melts with borax into a transparent glaſs." (Ibid 540.)

CINNAMON STONE—inſtantly fuſed into a black globule with violent ebullition.

SPINELLE RUBY—fuſed immediately into an elliptical red globule. " It does not melt before the blow pipe but is fuſed by the aid of borax. [Ibid 497.]

STEATITE—melted with ſtrong ebullition into agreyiſh ſlag.—" It does not melt before the blow pipe, but becomes white and very hard." [Ibid 482.]

Porcelain, common pottery, fragments of Heſſian crucibles, Wedgwood's ware, various natural clays, as pipe and porcelain clay, fire and common brick, and compound rocks, &c. were fuſed with equal eaſe.

During the action of the compound flame upon the alkaline earths, provided they were ſupported by charcoal, diſtinct globules often rolled and darted out from the ignited maſs, and burnt, ſometimes vividly, and with peculiarly coloured flame. From the nature of the experiments, it will not be eafy to prove, that thefe globules were the bafis of the earths, and yet there is the ftrongeft reafon to believe it; circumftances could fcarcely be devifed, more favourable to the fimultaneous fufion and decompofition of thefe bodies; charcoal highly ignited for a fupport and an atmofphere of hydrogen alfo in vivid and intenfe ignition; that the oxygen fhould be, under thefe circumftances, detached, is not furprifing, but the high degree of heat, and the prefence of oxigen neceffarily burn up the metalloids almoft as foon as produced. If means could be devifed to obviate this difficulty, the blow pipe of Mr. Hare might become an important inftrument of analitical refearch.

We can fcarcely fail to attribute fome of the appearances, during the fufion of the Leucite, to the decompofition of the potafh it contains.

This impreffion was much ftrenghtened by expofing potafh and Soda to the compound flame, with a fupport of charcoal; they were evidently decompofed: numerous diftinct globules rolled out from them, and burnt with the peculiar vivid, white light, and flafh, which these melalloids exhibit, when produced and ignited in the galvanic circuit. It is hoped that thefe hints may induce a farther investigation of this fubject.

The experiments which have now been related in connection with the original ones of Mr. Hare, fufficiently fhew that fcience is not a little indebted to that gentleman for his ingenious and beautiful invention.— It was certainly a happy thought, and the refult of very philofophical views of combuftion, to fuppofe that a highly combuftible *gafeous* body, by intimate mixture with oxygen gas, muft, when kindled, produce intenfe heat: and it is, no doubt, to this capability of perfectly intimate mixture, between these two bodies, that the effects of the compound blow pipe, are, in a great meafure, to be afcribed.

This communication has already been extended farther than was contemplated, but on concluding it, it may be allowable to remark, that there is now, in all probability no body, except ſome of the combuſtible ones, which is exempt from the law of fuſion by heat. If the primitive earths, and ſuch minerals, as several of thoſe which have been mentioned, above, are fuſible, no doubt can be entertained that all other mixtures and combinations of earths are fuſible alſo: for, ſuch mixtures and combinations are known to be more fuſible than the primitive earths; the metals are more fuſible than the earths, and the diamond along with carbon in its other pureſt forms, appears to be really the only exception; and it is probable that this is only a *ſeeming one*, for, it is scarcely poſſible to expoſe theſe bodies to the heat of the compound blow pipe, without at the ſame time burning them up: could the heat be applied without expoſing them to the contact of oxigen is it not probable that they alſo would be added to the liſt of fuſible bodies?

Yale College, May 7, 1812.

No. XXI.

OBSERVATIONS

On the Comet of 1811.

By JEREMIAH DAY, Prof. of Math. and Nat. Philo. in Yale College.

ON the 9th of September laſt, I began a courſe of obſervations, on the Comet which has lately withdrawn from our view. They were continued, with conſiderable intervals of interruption, till the 13th of January. Though I was poſſeſſed of no inſtrument, which would give the place of the Comet, with the utmoſt preciſion; yet the obſervations were ſufficiently correct, for a determination of the elements of its orbit, with a near approach to exactneſs.

Few Comets have preſented themſelves to our view, under circumſtances more favourable, for obſerving their motions. Many have appeared for a few days, and then, ſuddenly retired. But this was viſible, for ſeverable months, even to the naked eye. During this period, it traverſed a ſpace, of more than 130 degrees, in the heavens. A general idea of the direction of its motion may be obtained, by conceiving a great circle to be drawn through the ſtar η, in the extremity of the tail of the Great Bear; and the bright ſtar in the Eagle. It was near the firſt of theſe, on the 2d of October; and very near the latter, on the 1ſt of December, as Mr. Bowditch had predicted, two months before. It paſſed acroſs the conſtellation of the Great Bear, the head of Aſterion, the right arm of Bootes, the northern part of Hercules, the Eagle, and the bow of Antinous; and when I ſaw it laſt, on the 13th of January, it was a little ſouth of the head of Equuleus. Clouds intercepted the view of it, one or two of the following evenings; then ſucceeded a period of moonlight; and, when the moon had paſſed the full, the comet had advanced too near the ſun, to be longer viſible. I had found its place, from time to time, by taking its diſtance from ſome of the principal fixed ſtars, with a ſextant, graduated to every ten ſeconds. The time was given, by a well regulated clock. To diminiſh the errours of obſervation, each of the diſtances was generally meaſured ten or twelve times in ſucceſſion, and a mean taken from the whole. The requiſite corrections, for the refraction of the atmoſphere, were afterwards applied. The following are ſome of the obſerved diſtances. Two or three of the firſt are not probably very correct, as they were taken, when the comet was ſo near the horizon, as to render the view of it obſcure, and the refraction uncertain.

	Apparent time.			*Dist. from Arct.*			*Fr. γ Ursæ. Maj.*		
		h.	*m.*	°	′	″	°	′	″
Sept.	9th,	8	9	45	38	26	15	18	10
	13	8	31	42	46	30	11	59	40
	16	8	7	40	26	8	10	0	34
	17	8	17	39	44	26	9	26	38
	18	8	28	38	57	10	8	50	28
				From α Lyræ.			*β Ursæ Min.*		
Oct.	11	8	47	37	12	54	27	33	54
	17	8	52	27	20	0	32	22	39
	18	9	3	25	47	12	33	24	24
							α Aquilæ.		
	27	8	4	13	56	30	41	6	12
	28	8	10	13	6	54	39	27	38
Nov.	3	7	46	11	53	4	30	19	4
	4	7	50	12	17	18	28	53	12
	12	7	18	18	14	7	18	38	4
	14	7	49	20	1	43	16	18	49
	15	7	23	20	54	54	15	14	5
	22	6	52	26	43	17	8	16	34
	24	7	37	28	17	14	6	30	4
Dec.	8	6	8	37	28	24	3	57	48
	10	7	8	38	34	20	5	13	20
	12	7	36	39	39	32	6	25	40
	16	6	53	41	39	3	8	41	25
	20	6	40	43	30	43	10	48	5

This comet came to us, from the regions of the ſouth. It croſſed the ecliptic on the 11th of July, and advanced ſo far to the north, that on the 28th of September, it was within the circle of perpetual apparition of this latitude, and, of courſe, continued above the horizon, the whole 24 hours. In two or three days from this, it reached its greateſt northern declination, about 50 degrees; and then began to return towards the equator. But it did not attain its higheſt geocentric latitude, till the middle of October. Its apparent place was then, within 28 degrees of the pole of the ecliptic. Its motion as ſeen from the earth, was, during the months of September and October, nearly in the arc of a great circle. But the latter part of the time, in which it was viſible, it ſenſibly deviated to the eaſt of its former direction; though, on account of its moderate angular velocity, its elongation from the ſun was then rapidly diminiſhing. The rate of its apparent motion has been leſs, than that of many other comets. One ſeen in 1472 moved 40 degrees, and another in 1770, 45° in 24 hours. But the progreſs of the late comet never exceeded two degrees in 24 hours: and during the latter part of the time, it did not amount to half a degree.

This is a general view, of the *apparent* motion of the comet, to a ſpectator on the earth. But its *real* motion will be found to be widely different: ſo much ſo, that, while the apparent motion was, moſt of the time, towards the eaſt; its real motion in longitude was weſtward, or contrary to the order of the ſigns. To determine the direction and rate of this motion, it was neceſſary to refer it to the *sun*, as a centre, and to calculate the *elements* of the comet's orbit. Theſe are the perihelion *diſtance*, the *time* of paſſing the perihelion, the *longitude* of the perihelion, the longitude of the *node*, and the *inclination* of the orbit to the ecliptic. To obtain a firſt approximation, to the time and diſtance of the perihelion, ſome of the early obſervations were made uſe of. But for the final corrections, it was neceſſary to take ſuch, as had a greater interval of time between them. The obſervations, of the 17th of September, the 17th of October, and the 14th of December were accordingly ſelected: and the elements were corrected by the method of La Place, as given, in Sir Henry Englefield's treatiſe on the "Determination of the orbits of Comets." To ſucceed with this method, it was neceſſary that the elements ſhould be very carefully prepared. For the convenience of calculation, the three obſervations were reduced to 8 o'clock, mean time at Yale College, by applying to the obſerved diſtances, a proportional part of the diurnal variation. The right aſcenſion and declination of the ſtars, from which the diſtances of the comet had been taken, were found, by comparing the catalogues of Dr. Bradley, De La Caille, Piazzi, Zach, Wollaſton and Pond, in Vince's Aſtronomy, Hutton's Dictionary, Rees' Cyclopedia, and Mendoza's Tables. Theſe generally agreed, within a very few ſeconds, with reſpect to the ſtars in queſtion. The corrections, for preciſion, aberration, and nutation were applied; and from the right aſcenſions and declinations, the latitude and longitude of the ſtars, were calculated to ſeconds; as were alſo the geocentric latitudes and longitudes of the comet. The latter were farther corrected, by applying the equations, for the aberrations of light. The three latitudes and longitudes thus obtained, were,

	Geocen. Lon.	*Latitude.*
September 17,	153° 34′ 36″	38° 39′ 56″
October 17,	221 54 28	62 27 43
November 14,	286 9 15	41 50 53

Taking theſe, and the approximate perihelion diſtance and time, as the baſis of the ſucceeding calculation, I proceeded to derive from the comet's obſerved longitudes and latitudes, the arc which it deſcribed, between the firſt and ſecond obſervation; and alſo between the ſecond and third; for the purpoſe of comparing them with the correſponding arcs, obtained by taking the difference of the three anomalies. If theſe had been found to agree; no other correction of the elements would have been requisite, to adapt them to the three observations. But this was not to be expected, on the first trial. There was a difference of several degrees. It was necessary therefore to make a second, and a third hypothesis, in one of which, the perihelion *distance* was changed, and, in the other, the *time* of perihelion. From the errours of the three, the equations were formed, for determining the corrections to be applied to the assumed elements. After two sets of hypotheses, a perihelion distance, and time of perihelion were obtained, which gave the arc described by the comet, betweed the 17th of September and the 14th of November, and measured by an angle at the sun, within less than half a minute of that deduced from the observed longitudes and latitudes:

The one being	58° 26′ 14″
The other	58 25 52
Difference	0° 0′ 22″

As this difference is within the limits of the unavoidable errours of observation, I did not attempt to carry the approximation any farther. Some slight variations would probably have been made, by processes depending on a comparison of *all* the observations. But as they would be of little amount; and as *perfect* accuracy would not be attainable after all; I proceeded to calculate the remaining elements, from the two already found. The whole together were as follow:

Perihelion distance 1.0329; the mean distance of the sun from the earth being 1.

Time of perihelion Sept. 12th, 1 o'clock, P. M. mean time at Greenwich.

	s.		
Longitude of the ascending node,	4	20°	22′
Inclination of the orbit to the ecliptic,		73°	4′
Longitude of the perihelion, counted on the orbit,	2	15°	14′
Distance of the perihelion from the node,	2	5°	8′

Motion retrograde.

The following diſtances of the comet from the earth, and the ſun were alſo calculated :

Diſtances from the earth.

	In semidiam. of the earth's orbit.	*In miles.*
July 10th,	2.411	229,045,000
September 17th,	1.512	143,670,000
October 17th,	1.224	116,290,000
November 14th,	1.591	151,145,000
December 16th,	2.359	224,070,000

Diſtances from the Sun.

	Semidiam. of earth's orbit.	*Miles.*
Sept. 12th	1.0329	98,125,500
Sept. 7th and 17th,	1.0367	98,490,000
Sept. 2d and 22d,	1.0470	99,470,000
Aug. 23 and Oct 1,	1.081	103,000,000
Aug. 8 and Oct. 17,	1.189	113,000,000
July 23 and Nov. 1,	1.323	126,000,000
July 11 and Nov. 14,	1.463	139,000,000
June 23 and Dec. 1,	1.655	157,000,000
June 9 and Dec. 16,	1.831	174,000,000
May 23, 1811, and Jan'y 1, 1812,	2.022	192,000,000
April 22, 1811, and Feb. 1, 1812,	2.385	227,000,000

In addition to the elements given above, one thing farther is neceſſary to complete the theory of the comet's motion—the period of its revolution. This is an article on which much labour has heretofore been beſtowed, with very little ſucceſs. Two methods are obviouſly ſuggeſted, for determining the time of a comet's return. The moſt direct of theſe, is to derive, by calculation, the figure and dimenſions of the *whole* orbit, from that ſmall part of it, which is deſcribed, while the comet is viſible. It reſults from the well known laws of gravitation, that any body, moving round the ſun, and influenced by the attraction of no other body, muſt move in one of the three conic ſections, the ellipſis, the parabola, or the hyperbola. If it is ever to return, in a regular orbit, it muſt revolve in an ellipſis. If its motion is in either of the two other figures, after having once paſſed the perihelion, it will continually recede from the ſun, and will return no more; unleſs its direction ſhould be changed, by the attraction of ſome other body. In each of theſe caſes, however, if a portion of the path of a comet could be obtained by obſervation, with *perfect exactneſs*; from this might be deduced, the remaining parts of the orbit, on the ſuppoſition, that its figure ſhould remain unaltered. But here two inſuperable difficulties occur, one from the errours of obſervation, the other from the liability of the comet, to be diverted from its courſe, by the attraction of the planets, and perhaps of the fixed ſtars. The ground of theſe difficulties, lies not in the proceſses for *calculating* the orbit; but in taking the obſervations, and in the change of the orbit itſelf. Errours too minute to be avoided, even by the niceſt inſtruments hitherto in uſe, might be ſufficient, in certain caſes, eſpecially where the orbit is very eccentric, to make a variation of many years, in the periodical time. The moſt able computers, have accordingly differed whole centuries, in the periods, which they have reſpectively aſſigned to the ſame comet. The only caſes to which calculation can be applied, with any hope of ſucceſs, are thoſe in which the time of revolution is very ſhort. The comet of 1770, has been ſuppoſed to be one of this claſs. Lexell, Pingre, and Burckhart all agree in giving it a period of about five years and an half. There is reaſon to believe, that this is the orbit, which really correſponds with that part of its motion, which was obſerved. But notwithſtanding this, the comet has never been ſeen ſince; though it ought to have returned ſix or eight times, in the intervening forty years.

If its orbit was truly aſſigned, it ſeems it muſt have been ſince altered, by the attraction of the planets or of ſome other body, whoſe influence may be ſufficient, not only to vary materially the time of revolution; but even to change the comet's path, from an ellipſis, to a parabola or hyperbola, ſo that it ſhall *never* return.

The ſecond method, which has been adopted, for aſcertaining the periodical time of a comet; and, on which conſiderable reliance has been placed, is, to compare the elements which are commonly computed, with thoſe of all the other comets, on which calculations have been made. If ſeveral of them are found to have the ſame elements; it is concluded they muſt be one and the ſame comet. For it is ſcarcely credible that in the endleſs variety which is found to prevail, in the directions and rate of their motions, there ſhould be any two, which ſhould have preciſely the ſame perihelion diſtance, the ſame longitude of their nodes, the ſame place of perihelion, and the ſame angle of inclination to the ecliptic: and, in addition to all this, that they ſhould appear at intervals of time ſo regular, as to correſpond with the ſucceſſive returns of the ſame comet. On this ground, it has been ſuppoſed, that the comet of 1759 has a period of about 75 years, becauſe one with ſimilar elements was ſeen in the years 1456, 1531, 1607, and 1682. But no ſuch correſpondence is found, in the caſe of the late comet. From a compariſon of its elements with others whoſe motions have been heretofore obſerved and calculated; it will be ſeen that this is one, which is not included in the liſt. In perihelion diſtance, it nearly agrees with one, which appeared in 1718; but differs from it, more than 40 degrees, in the inclination of the orbit. In the longitude of the node, it is within leſs than a degree of that in 1759; but varies materially from it, in the longitude and diſtance of the perihelion. In the inclination of the orbit, it differs but little from one in 1097 and another in 1763; but has no agreement with them, in the other elements. So that this method of determining the periodical time fails, in its application to the preſent caſe. And even, if the elements of this comet, had been found to agree, with thoſe of any preceding one; it would have ſerved rather to ſhew, in what interval of time it *has* returned, than to give us assurance, that it *will* return, at the same interval, hereafter. The reasons of this, have already been stated to the Academy, by Col. Mansfield, in his ingenious remarks, on the comet of 1807.

The motion of the late comet, as seen from the sun, was nearly north and south; inclining however, about 17 degrees, towards the northwest and southeast. It passed northward, through the constellations of the Lion, the Great Bear, and the Camelopard. On the 19th of September, to a spectator in the sun, it was within three degrees of that part of the heavens, to which the axis of the earth is directed. It reached its greatest northern heliocentric latitude 73 degrees, on th 1st of October; and then returned, through Cepheus, the left wing of the Swan, Equuleus and Aquarius. It will proceed through the Microscope, the Indian, and the Octant; till, at its greatest distance from the earth, it will be between the Chameleon and the Flying-fish, within 17 degrees of the south pole of the ecliptic. Should it visit us again, it will return through the Ship, the Air-pump, Hydra and the Sextant.

This comet has not approached so near to the sun, as most of those, whose elements have been calculated. Its least distance, is 98 millions of miles; a little greater than that of the earth from the sun. Its path lies between the orbits of the earth and Mars. It is the opinion of Newton, that no comet is ever seen by us, when farther distant than Jupiter. Of about one hundred, whose elements have been calculated, all, except four, have come nearer to the sun than Mars. These four fell between Mars and Jupiter. About 20 came between Mars and the earth; 15 between the earth and Venus; nearly 30 between Venus and Mercury; and about the same number, within the orbit of Mercury. The remarkable one of 1680, came much nearer to the sun, than any other: so near, as to be heated, according to Newton, 2000 times hotter than red hot iron. Its least distance, from the surface of the sun, was not equal to a fifth part of his diameter.

There is no danger, that the late comet will ever ftrike the earth ; unlefs its orbit fhould, hereafter, be materially changed. Its leaft diftance, in the prefent inftance was more than an hundred million miles. This was about the middle of October. Its neareft approach to the *orbit* of the earth, was on the 11th of July, about 40 million miles. It can never come much nearer than this, without a change in the pofition or figure of its orbit. Its rate of motion, when neareft the fun, was 95,000 miles in an hour. This is a velocity, 120 times greater than that of found, or a cannon ball.

For the purpofe of determining, if practicable, the *size* of the comet, I viewed it feveral times, through a three feet reflecting telefcope, with a magnifying power of 140. But I was unable to perceive any nucleus, with a difk fufficiently defined, to admit of meafuring its diameter. This will not appear furprifing, when it is confidered, that out of 15 or 20 comets, which Dr. Herfchel has had an opportunity of obferving, there were only two or three, on which he was able to difcover any regular difk, even with the very powerful telefcopes in his poffeffion. For want of a proper regard to the diftinction between the different parts of a comet ; no great dependence is to be placed, upon the accounts given us, of the fize of thofe, which were formerly feen. They have been frequently reprefented, as larger than any of the planets ; and, in fome inftances, as appearing nearly equal to the fun and moon. Thefe ftatements may be true, if they are meant to refer to the *whole* of the luminous fpot, or body of light, which is perceived, by the naked eye. But this, in many cafes at leaft, confifts of three parts —the nucleus, the head, and the coma. The nucleus appears to be a compact fpherical body, with a circumference regularly defined, like a planet. The head, is a body of denfe light, which, like an atmofphere, furrounds the nucleus. The coma, is a fpace occupied by a fainter light, extending confiderably farther round, than the head. All thefe may be fo blended, to the view of the naked eye, as to appear to conftitute but one body of light; ſo that the diameter of the coma may be taken, for the diameter of the comet itſelf. A teleſcope, by expanding the head, often makes it appear leſs bright, and leſs diſtinct. It ſpreads it out, into a kind of nebula, which has no well defined boundary; but which may, notwithſtanding, be miſtaken for the nucleus. The latter is generally too ſmall, to be diſtinctly perceived, by ordinary teleſcopes; and in many inſtances, cannot be diſcovered, by thoſe of the greateſt magnifying power. That of 1807, according to Dr. Herſchel, ſubtended an angle of only one or two ſeconds; while the diameter of the coma was two or three hundred times as great La Place and others have even advanced the opinion, that the whole body of the comet is ſometimes a mere collection of aeriform fluids, moſt condenſed near the centre, but containing no ſubſtance ſufficiently compact, to obſtruct entirely the paſſage of light. In the preſent inſtance, I obſerved nothing, which could either invalidate or confirm, ſuch an hypotheſis. The head appeared, like an obſcure cloud or miſt. The coma was nearly of the ſame brightneſs with the tail. A darker ſpace, or a zone of weak light, very perceptibly fainter than either the head, or the coma, intervened between the two.

The tail of this comet, was more ſplendid, than is common: though ſome others have exceeded it, both in brightneſs and extent. That of 1680, was two or three degrees in breadth, and about 70, in length. That of 1759 was, according to Pingre, 90° long. One in 1618 is ſaid to have extended more than a hundred degrees.

The length cannot be meaſured, with exactneſs. For the extremity does not terminate at once; but gradually diminiſhes in brightneſs, till it is loſt, in the ſtill fainter light of the ſky. The dimenſions will vary, according to the ſtate of the atmoſphere. They will even appear different, to different eyes, at the ſame time. About the middle of October, I judged the tail of this comet to be nearly or quite 15 degrees long. It could not be leſs than twelve. If it be taken at 12° on the 17th;

and the breadth at half a degree; it will be found, by calculation, that the length in miles, was 40,000,000; and the breadth 1,000,000: the whole occupying a ſpace, which would not be filled by 60 million ſuch globes as our earth.

Stars were frequently to be ſeen through the tail; though they were conſiderably obſcured. That ſide of it, which was turned towards the part of the heavens, to which the comet was moving, was a little convex, as uſual, and brighter than the oppoſite ſide. I repeatedly obſerved a dark line, like a ſhadow, extending from one end of its tail, to the other; and paſſing nearly through the middle, but a little further from the advancing ſide, than from the other. The whole appearance was ſuch, as to correſpond very well with the ſuppoſition, that the tail was hollow. The light was denſeſt on each ſide, and gradually diminiſhed, towards the middle, where was a narrow ſpace, almoſt as dark as the neighbouring parts of the ſky. This peculiarity has not been mentioned, in the accounts of other comets, except in a few inſtances. Hevelius ſtates, that one which he ſaw in 1665, caſt a ſhadow through the middle of the tail. A ſimilar appearance was obſerved in the comet of 1744; and alſo by Caſſini, in that of 1680.

I have not entered into any ſpeculations on the *nature* and *uſe*, of this wonderful train of light, which is as unaccountable, to the aſtronomer, as to the vulgar obſerver. Some extravagance of conception is certainly excuſable, in attempting to explain the conſtitution of a luminous object, which occupies a greater ſpace, than all the other bodies in the ſolar ſyſtem. But the ſchemes which have hitherto been propoſed, for this purpoſe, are rather to be conſidered as diſplays of the power of imagination; than ſpecimens of the exerciſe of ſound and ſober reaſon. Thoſe who have a taſte for theſe viſionary hypotheſes, may eaſily contrive them for themſelves; or may find, in the common aſtronomical works, a very convenient aſſortment of them, adapted to the fancy, of almoſt every deſcription of readers.

Yale-College, March 20th, 1812.

No. XXII.

CALCULATION

Of the Longitude of Yale-College, from the Solar Eclipſe of September 17th, 1811.

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IT is important, that the Latitude and Longitude of places, eſpecially of thoſe in which aſtronomical obſervations are to be made, ſhould be ſettled, with as much accuracy, as the nature of the caſe will admit.

The Latitude is eaſily obtained, from the meridian altitudes of the ſun, and the fixed ſtars. But ſome more complicated proceſs is neceſſary, for determining the Longitude. Moſt of the methods in uſe, for this purpoſe, depend on the motion of the moon in her orbit. Several of them, however, cannot be relied on, to give the longitude, with any great degree of accuracy That founded on the obſervation of ſolar eclipſes, has an advantage in this reſpect, over moſt of the others. As we had ſeen no circumſtantial account of any attempt, to aſcertain the longitude of Yale-College; we made preparations, to avail ourſelves of the opportunity furniſhed, by the eclipſe of the ſun, of Sept. 17th 1811. The going of the clock, from which the time was to be taken, was carefully attended to, for ſeveral months preceding. Its rate was found, by obſerving the paſſage of the ſun and fixed ſtars, acroſs the meridian. A tranſit inſtrument, with a teleſcope of about twenty inches focus, had been fixed, under the cupola of the Lyceum, nearly two years before. Care had been taken, during this period, by repeated obſervations of the pole ſtar, to obtain an accurate adjuſtment of the teleſcope in the plane of the meridian.

When the meridian was ſatisfactorily determined, an object was placed in view, nearly two miles diſtant, by which the inſtrument might afterwards be eaſily adjuſted at pleaſure.

The day of the eclipſe was remarkably fine. Scarce a cloud was to be ſeen, the whole time the ſun was above the horizon. There was little or no wind, to diſturb our obſervations. One of us was ſtationed at the clock; while the other was looking at the ſun, through a three feet reflecting teleſcope. The eclipſe was perceived, almoſt, if not quite, at the inſtant of its commencement. The time of the end was obſerved, with no leſs exactneſs.

The rate of the clock was determined, by obſervations on the meridian tranſits, of the ſun, and of the fixed ſtars, on that and the preceding and following days. It was found to loſe eight ſeconds, in twenty-four hours. The paſſage of the ſun, acroſs the meridian, on the day of the eclipſe, was very carefully obſerved with the tranſit inſtrument. The time, by the clock, was 11h—54′—9.5″

The following were the obſervations of the beginning and end of the eclipſe.

	h.	*m.*	*s.*
Beginning, by the clock, - - - -	0	38	22
Clock slower than the sun, - - -	0	5	50.5
Allowance for the rate of the clock, - -	0	0	0.2
Apparent time of beginning, - - -	0	44	12.7
Time of end, by the clock, - - -	3	46	5
Clock slower than the sun, - - -		5	50.5
Allowance for the rate of the clock, - -	0	0	1·3
Apparent time of end, - - - -	3	51	56.8

To find the latitude of the place, the meridian altitude of the ſun, was repeatedly taken, with an Equatorial Inſtrument, containing a teleſcope of 18 inches focus. The mean of twelve obſervations, was very nearly 41°—18′. The latitude is taken at this, in the following calculations; and the reductions of parallax and latitude are made, according to that eſtimate of the figure of the earth, which gives the proportion of the polar to the equatorial diameter, as 300 to 301.

From theſe data, the longitude might be calculated, if the ſolar and lunar tables could be relied on, as perfectly correct. But it is well known that they are liable to an errour, which might materially affect the reſult. It is neceſſary, therefore, that the tables ſhould be corrected, or that the time of true conjunction ſhould be obtained, from obſervations, at ſome place or places, whoſe longitude is already known. For this, we are indebted to a very obliging communication from Nathaniel Bowditch Eſq. of Salem; on whoſe accuracy in calculation, full reliance may be placed: and who had undertaken to collect the obſervations, which were made on the eclipſe, in different parts of the United States. He finds the time of true conjunction to be at 6h. 57′. 05.8″ apparent time at Greenwich; the longitude of the ſun and moon, at that time, 173° 56′ 32.4″; and the moon's Latitude 36′ 40.2″ North. The Following are the calculations for the longitude at Yale College.

For the parallaxes, &c. at the beginning of the Eclipſe.

	h. m. s.
Apparent time of beginning at Yale-College,	0 44 12.7
Assumed difference of Longitude, -	4 51 50
Apparent time at Greenwich, - -	5 36 02.7
Sun's Right Ascension in time, -	11 37 34
Sun past meridian, - - - -	0 44 12.7
Correction for the sun's advance, - -	+ 0.7
R. ascension of mid-heaven, in time, -	12 21 47.4
Do. - - - in degrees, -	185° 26′ 51″
Distance of meridian from Capricorn, -	84 33 09
	h. m. s.
Apparent time of beginning - - -	5 36 02.7
Do. of conjunction, (from Mr. Bowditch) -	6 57 05.8
Time from beginning to conjunction, -	1 21 03.1
Moon's Lon. at conjunction, - -	173° 56′ 32″.4

Motion in 1 hour, (by Burg's tables,) -			0° 29′ 32″.7
Do. in 21m. 3.1s. - - - - -			10 22.9
Moon's Lon. at the beginning - -			173 16 36.8
Moon's Lat. at conjunction, - - -			36 40.2 N
Motion in 1 hour - - - - - -			2 43.22
Do. in 21m. 3.1s. - - - - -			57.28
Lat. at the beginning, - - - -			32 59.7
Dist. merid. from Cap.	84° 33′ 09″	Cos.	8.9774201
Co. Lat. reduced, -	48 53 20	Tan.	10.0591364
Arc I. - - -	6 12 30	Tan.	9.0365563
Dist. of the poles, -	23 27 42		
Arc II. - - -	17 15 12	Sin.A.C.	0.5278330
Arc I. - - -	6 12 30	Sin.	9.0340022
Dist. of merid. from Cap.	84 33 09	Tan.	11.0206140
Dist. of the nonagesimal from Cancer,	75 20 34	Tan.	10.5824492
Add - -	90		
Lon. of nonagesimal,	165 20 34		
Lon. of the moon	173 16 36.8		
Dist. of the moon E. fr. non.	7 56 02.8		
Dist. of the non'l. fr. Cancer	75 20 34	Cos.	9.4031818
Arc II.	17 15 12	Tan.+10	19.4921624
Alt. of nonagesimal	50 49 44	Tan.	10.0889806
Moon's equa. hor. paral. 53′ 59″.9 =	3239″.9		
Reduc. for Lat. 41° 18′	—4.7		
Moon's reduced hor. par.	3235.2		
Sun's horizontal parallax -	8.7		
Hor. par. of moon from sun,	3226.5	Log.	3.5087317
Altitude of the nonages.	50 49 44	Sin.	9.8894491
Moon's Lat. - -	0 32 59.7	Cos.A.C.	0.0000200
		Log.	3.3982008
Dist. of the moon from non.	7 56 02.8	Sin.	9.1399868

Approximate par. in Lon.	5′ 45.3″	Log.	2.5381876
			3.3982008
Dist. of moon from non. + par. in lon.	8 1 48.1	Sin.	9.1451717
Correct par. in lon. 349.5″ =	5 49.5	Log.	2.5433725
Hor. par. of moon from sun,	3226.5″	Log.	3.5087317
Alt. of the non. -	50 49 44	Cos.	9.8004686
1st Part of par. in lat. 2038″ =	33 58	Log.	3.3092003
2d Part - - - - -	0.7		
Correct par. in Lat. -	33 58.7		
Moon's true Lat. -	32 59.7 N.		
Moon's apparent lat. -	0 59 S.		

Moon's hor. semid.	14′ 44.27″
Inflexion, -	−2
	14 42.27
Augment. for 50° alt.	+ 10.73
Moon's cor. semid.	14 53 = 893″
Sun's semid.	15 57.2
Irradiation,	− 3.5
Sun's cor. semid.	15 53.7 = 953.7

Sun and moon's semidiameters	1846.7		
Moon's appar. Lat. - -	59		
Sum, - - - -	1905.7	Log.	3.2800545
Difference, - - -	1787.7	Log.	3.2522946
			2)6.5323491
Appar. Lon. of moon from sun,	1845.76	Log.	3.2661745
Par. in lon. - - -	+ 349.5		
True lon. of moon from sun,	2195.26		

Moon's hourly mo. in lon.	29′ 32.7″
Sun's do. - -	2 26.55

Hourly mo. fr. sun 27′ 06.15″=	1626.15″	Log. A.C.	6.7888394
One hour, - - -	3600	Log.	3.5563025
Lon. of moon from sun, -	2195.26	Log.	3.3414860

Time from beginn. to conjunction,	*h. m. s.* 1 20 59.9=	4859.9	Log.	3.6866279
Time of begining,	0 44 12.7			
Time of conj. at Y.C.	2 05 12.6			

For the Parallaxes, &c. at the end.

	h. m. s.
Apparent time of end,	3 51 56.8
Assumed differ. of lon.	4 51 50
Apparent time at Greenwich,	8 43 46.8
Sun's Right-ascen. in time,	11 38 02
Sun past meridian,	3 51 56.8
*Cor. for the sun's advance,	+ 3.4
R. Ascen. of mid heaven	15 30 02.2
Do. in degrees,	232° 30′ 33″
Dist. of merid. from cap.	37 29 27
	h. m. s.
Appa. time of end,	8 43 46.8

* Note. This correction, which depends on the difference in the equation of time, on two fucceffive days, is generally omitted, in the rules which are given, for finding the right afcenfion of midheaven; probably becaufe it is of fmall account. But, in ftrict propriety, it ought to be included. In the prefent inftance, it will make a difference, of more than a minute, in the longitude of the nonagefimal. The equation of time is 21 feconds greater, on the 18th of Sept, than on the 17th. The fun therefore, in twenty four hours, not only makes a complete revolution; but, in addition to this, falls to the weft of the meridian, fuch a diftance, as correfponds to 21 feconds of time. A proportional part of this, fhould be allowed, for the time between 12 o'clock, and the end of the eclipfe.

Do. of conjunction,	6 57 05.8		
Time from conjunc. to end	1 46 41		
Moon's lon. at conjunc.	173° 56′ 32.4″		
Motion in one hour,	29 33.2		
Do. in 46m. 41s.	22 59.6		
Moon's long. at the end,	174 49 05.2		
Moon's lat. at conjunc.	36 40.2 N.		
Motion in one hour.	2 43		
Do. in 46m. 41s.	2 06.8		
Moon's lat. at the end,	41 30		
Dist. merid. from cap.	37° 29′ 27″	Cos.	9.8995200
Co. lat. reduced,	48 53 20	Tan.	10.0591364
Arc. I.	42 16 37	Tan.	9.9586564
Dist. of the poles,	23 27 42		
Arc. II.	18 48 55	Sin. A. C.	0.4914459
Arc. I.	42 16 37	Sin.	9.8278310
Dist. of merid. from cap.	37 29 27	Tan.	9.8848366
Dist. non. from cap.	57 59 39	Tan.	10.2041135
Subtract this from	270		
Lon. nonages.	212 0 21		
Lon. of the moon,	174 49 05		
Moon from non.	37 11 16		
Non. from cap.	57 59 39	Cos.	9.7242805
Arc. II.	18 48 55	Tan.+10.	19.5324044
Alt. of non.	32 44 09	Tan.	9.8081239
Hor. par. of moon fr. sun.	3227.2″	Log.	3.5088124
Alt. of nonages.	32 44 09	Sin.	9.7330098
Moon's lat.	0 41 30	Cos. A. C.	0.0000316
		Log.	3.2418538
Moon from non.	37 11 16	Sin.	9.7813454
Approx. par. in long.	17 35	Log.	3.0231992
		Log.	3.2418538
Mo. from non. + par.	37 28 51	Sin.	9.7842577

Cor. par. in long.	1062″ = 17′ 42″		Log.	3.0261115
Hor. par. mo. from sun		3227.2	Log.	3.5088124
Alt. of the non.		32 44 09	Cos.	9.9248852
1st part of par. in lat.		45 14.54	Log.	3.4336976
2d part of do.		.16		
Cor. par. in lat.		45 14.7		
Moon's true lat.		41 30		
Moon's appar. lat.	224.7	= 3 44.7 S.		
M's. semid.–inflex.	14 42.5			
Aug. for 25° 30′ alt.	+6.1			
Mo's. cor. semid.	14 48.6			
Sun's do.	15 53.7			
Sun and mo's. sem.	30 42.3	= 1842.3″		
Mo's. app. lat.		224.7		
Sum		2067.	Log.	3.3153405
Difference,		1617.6	Log.	3.2088711
				2)6.5242116
Appar. long. of moon from sun		1828.55	Log.	3.2621058
Par. in Lon.		1062.		
True long. of moon from sun,		2890.55		
Mo's. hourly mot.	29 33.15			
Sun's do.	2 26.55			
M's. hourly mot. from sun,	27 06.6	= 1626.6	Log.A.C.	6.7887192
One hour,		3600	Log.	3.5563025
Long. of m. fr. sun		2890.55	Log.	3.4609805
	h. m. s.	*s.*		
Time fr. conj. to end	1 46 37.4	= 6397.4	Log.	3.8060022
App. time of end	3 51 56.8			

App. time of conj.	2	05	19.4
Do. cal. from begin.	2	05	12.6
Mean,	2	05	16
Conj. at Greenwich	6	57	05.8

	h	m	s		°	′	″
Dif. of long.	4	51	49.8	=	72	57	27.

It would have been desirable, to obtain a correction of the tables, from observations, made at the first meridian at Greenwich; that our calculation might not be affected, by the small errours, to which the longitudes of all places in the United States are liable. But as this eclipse was not visible in Europe, we have had recourse to observations made here, to determine the latitude and longitude of the moon, and the true time of conjunction.

Yale College, Nov. 24, 1812.

OBSERVATIONS

ON

LANGUAGE.

By the Rev. TIMOTHY DWIGHT, *S. T. P. LL. D.*

IT is a primary principle in all researches concerning language, *that nations will uniformly have such words, as express those ideas, which they wish to communicate.* Equally true is it, *that they will, for no length of time, retain any other.* Other words may be retained in books; but they will be lost out of the customary speech.

What is true, in this respect, of nations, is equally true of smaller classes of mankind. Thus lawyers, chemists, mariners, miners, &c. have a peculiar language of their own; made up of many words, unused, and ordinarily unknown, by other persons, belonging to the same nations. This partial, local language descends, also, from generation to generation in these classes of men, severally, as those of nations to their posterity.

This scheme admits of no exception; but is an absolute, as well as universal, law of language. From it many truths may be learned, which are of great importance in the philosophy of man; and may be learned with more ease, and more certainty, than in any other manner. For example; the character of a nation may with absolute certainty be extensively known from this source. The Latin language contains many terms, employed about *war;* that of the Greeks, many terms, expressive of the several ideas pertaining to *art*, and *science;* that of the Hebrews, many, denoting things, belonging to *morality* and *religion;* and that of the French, many, expressive of *the various modes, and circumstances, of polite intercourse.* Were we absolutely destitute of any history of these nations, and yet possessed of vocabularies, containing such words, as have been here alluded to; and were we assured, that the several classes of words had been in customary use among them, respectively; we should know with indubitable certainty, that the *Romans* were a military; the *Greeks*, a learned, and philosophical; the *Hebrews*, a religious; and the *French*, a polished people.

Equally evidential are the words, found in any language, of the pursuits, and other circumstances, of the people, by which it was used. After what has been said, little needs to be added on this part of the subject. If we know, that a man is a seaman, because he customarily uses nautical phraseology; we as certainly know, that a nation, whose language contains many commercial terms, is a commercial nation. The English language abounds in words, expressive of the rights, privileges, and duties, of freemen. This fact is a complete proof, independently of all history, that they have been much occupied in enjoying, and maintaining, these rights and privileges; and in performing these duties: in other words, that they have been a nation of freemen.

It follows, irresistibly, from this principle, that in all cases, where nations no longer wish to communicate certain ideas, which they have been accustomed to make, in some degree, subjects of their conversation, the words, which denote such ideas, will be dropped out of their speech. This is one of the great sources of what is called *the flux* of languages. The reason, why a multitude of words, formerly belonging to the *English* tongue, are not now lost, except so far as they are preserved in ancient books, is, that they have prolonged their existence in glossaries.

Nor is it less evident, that, whenever nations imbibe new ideas, which they wish to communicate, they will regularly originate such words, as are necessary to express them. A multitude of such words are continually introduced into the English language, at the present time. The flux of languages is extensively derived, also, from *this source.* The present *chemical nomenclature* furnishes a strong example of a numerous, and systematical, addition, suddenly made in this manner to the principal languages of *Europe.*

From the observations, already made, we derive an obvious reason for the remarkable fact, *that one language contains words, to which there are no corresponding words in another.* A nation under a monarchical government has occasion to communicate few ideas concerning subjects, involved in a state of freedom. In a free State such words form a large vocabulary. When the people of *France* formed themselves into a republic, they were obliged to transfer many words, expressive of such ideas, out of the *English* into the *French* language. The modern nations of *Europe*, also, have for the same reason derived most of their technical terms from the *Greek* language.

In the *names of simple ideas,* all languages, it is believed, extensively agree; because most ideas of this sort are necessarily subjects of communication in every country.

Complex ideas are partly acquired from objects, presented to us in nature, or created in their existing forms by the power of GOD; or *they are formed in the mind,* in the three processes of *Composition, Abstraction,* and *Comparison.* The names of the former class will be extensively found in most languages; because the objects, whence they are derived, are found in most countries; and because they are, to a great extent, substantially alike, wherever they are found. Thus hills and mountains, valleys and plains, rivers, lakes, and the ocean, are the same things throughout the world. This is extensively true, also, of animals, vegetables, and minerals; and almost absolutely true of the appearances in the heavens. With respect to this class of objects, all languages must, in a great measure, necessarily agree.

The diversity in languages is chiefly confined to the names of Complex ideas, formed by the mind. By enlightened nations these invariably have been multiplied, exactly in proportion to their improvement in the progress of Society. By savages they are scarcely formed at all.

All ideas, of this class, are prompted by the exigencies of human life; by the demands of necessity, comfort, convenience, and pleasure. To a savage few demands of this nature occur. His comforts, conveniences, and pleasures, lie within a very narrow circle. By necessity, almost alone, is he, therefore, led to form such ideas: and the demands of necessity are always few.

Among civilized nations, (where necessaries are easily furnished,) comfort, convenience, and pleasure, multiply their calls without number. Hence the mind, ever intent upon answering them, is perpetually busied in forming those ideas, to which they conduct us. Hence men compound, abstract, and compare, endlessly: and the ideas, thus created, are increased ad libitum. In a general proportion, the words, which denote them, are increased, for the reason given above.

Savages, as truly as civilized men, have all the words, which express such ideas, as they have occasion to communicate: and a nation, or colony, falling back towards a state of savageness, although it will lose a great part of its former language, will still retain every such word.

From these observations it will be seen, that *the intelligence of any nation may be exactly estimated from its Vocabulary;* or from a dictionary, containing all its words. If the words, contained in such a book, are numerous; *and yet denote, severally, different ideas;* such a nation has, at some time, been extensively enlightened. If they are few; it is, and has been, proportionally unenlightened. The *English* language contains more such words than any other; and this fact proves with absolute certainty, that the nation, speaking it, possesses more ideas, which are communicated, than any other nation. The language of *Arabia* is said to be very copious. There are two ways, in which a language may become copious. One is that, already specified; in which words, denoting different ideas, are numerous. The other is the multiplication of synonimous terms. In the latter sense, the *Arabic* language may be copious. In the former sense, this is morally impossible; because the *Arabians* are, comparatively, an ignorant and uncivilized people. There was a period, when they were more enlightened. At this period they multiplied words, denoting different ideas: and these may be found in the remaining books of that age. But the terms, now in customary use, are certainly, and necessarily, few. The multiplication of synonimous words is a proof, not of national improvement, but of addiction to pleasure and amusement.

The state of human languages has long been a subject of philosophical enquiry. "How," it is asked, "came the languages of mankind to be what they are: so numerous; so diverse in their words; and so unlike in their form, and construction?"

When we enter upon this inquiry, the first consideration of importance, that presents itself, is *the Confusion of languages at the tower of Babel.*

Who were the people, affected by this remarkable dispensation of Providence? To this question, I answer, *A part of the sons of Ham, joined together with others, who descended from Shem, and Japheth. Nimrod*, who led this enterprize, associated with him, first, his brethren and other near connexions; and then, all within his reach, who, with the true spirit of *modern Jacobinism*, were impatient of the government both of GOD and man. These people, having busily employed themselves, for a season, in hunting wild beasts under the conduct of *Nimrod*, began to turn their weapons against their fellow-men. For this purpose they found the continuance of their Union indispensable. They had become a numerous and formidable body, when GOD commanded *them*, together with the rest of mankind, to disperse in different colonies, for the purpose of peopling the world. This command they determined to disobey. Accordingly, they proposed to build a very lofty tower, and surround it with a city; and to make these the principal seat of their empire. In their company were probably numbered all the restless, violent, unprincipled, spirits of the age; and these must, to some degree at least, have been found among the descendants of *Japheth*, and *Shem;* for they have ever since been found in every Society, however peaceable, under heaven.

That all the descendants of *Ham* were not included, we know; because we find *Abraham*, a descendant of *Shem*, a long time afterward understanding, and conversing easily, with the inhabitants of *Canaan*, and of *Egypt*, who were descendants of *Ham*.

Antecedently to the building of *Babel*, "*the whole earth was of one language, and of one speech.*" The Confusion of languages, in whatever manner, and in other respects to whatever degree, it was accomplished, extended so far, as we are directly informed, *that they did not understand one another's speech*, and were therefore obliged to desist from their favourite purpose of building the city and tower, which they had begun. Beyond this extent, the Scriptures give us no information concerning the subject.

If a person of intelligence should take a page of any work; and, as he read it, should insert two, or three, important words, or in many cases even one, in each sentence, from a language, which he did not understand; he would readily perceive, that the whole must be unintelligible to those, in whose language the composition was written. As God does nothing more than that, which is necessary for the accomplishment of his purposes; we should naturally conclude, that, if the dispersion of these builders had been the only object, intended by this dispensation, a change, amounting to little, or nothing, more than I have specified, was all, that was effectuated at this time. But, as this event was the beginning, and was intended to be the beginning, of the divisions of language, which have since taken place, the degree of this change cannot, without further evidence, be warrantably confined within the limits, here mentioned.

Should a project, said to have been originated in *Russia*, of *forming an universal nomenclature of human languages*, ever be completed; materials would be furnished for determining, exactly, their number and variety; and of course the degree, and the manner, in which changes in them have taken place. Until this shall have been done, the subject must remain in much obscurity.

The Second cause of change in language is *the involuntary tendency of man to vary his Pronunciation.* This is done from inadvertency, forgetfulness, and a general indisposition to exactness, either of attention, or practice. From all these causes many persons pronounce many words of their own language imperfectly. Of this fact we are almost every day witnesses. Where any considerable body of people are insulated; or have little intercourse with the rest of a nation; an imperfect manner of pronouncing becomes ultimately diffused through that body; and terminates in a *distinct dialect of the language.* In this manner, it is believed, were originated the dialects among the *Greeks*; and in the same manner were formed the *Yorkshire* and *West-country* dialects in *England.* Similar instances exist in *France*, *Spain*, and *Germany.*

It has often happened, that those, who have originated such dialectic pronunciation, are, for a long period, almost absolutely separated from the parent stock. In every such case the dialectic pronunciation becomes unintelligible to the nation at large, in such a degree, as really to constitute *a new, spoken language;* although the words may still be *written* in the original manner. The *Koreans*, and *Japanese*, were colonists from *China*; and easily correspond with the *Chinese* in their written language; but cannot be understood by them, when they speak. The *Tonquinese*, and *Cochin-Chinese*, colonies also of the same nation, are said, to a great extent, to speak a different language; and this, it would seem, chiefly, or wholly, from a diversity of pronunciation: the *Chinese* language being still the substance of those, spoken in all these countries.

In the progress of this change of pronunciation it has often happened, that *nations, as well as tribes, have lost, finally, the sounds of several letters, and adopted those of several others.* Among these none are more remarkable than the Greek Θ, and X. The Romans could not pronounce the Θ, and therefore rendered Θεος Deus. This is equally true of the *French*, the *Dutch*, and many other nations. The *English* retain the pronunciation of this letter. X seems to be found among most, or all, nations, who distinguish their pronunciation by a peculiarly strong emphasis. Thus it is used by the *Irish*, *Scotch*, the *Germans*, and other descendants of the *Teutonic* tribes. It is also used by the *Iroquois*, and some other *North-American* tribes. But it is lost out of the *English*, *French*, *Latin*, &c. In the *Irish* it is expressed by *gh;* in the *Scotch*, by *ch;* as *Lough*, *Loch*. The syllables, which terminate in *English*, in *gh*, were originally pronounced in the same manner. But the *gh* is now either *quiescent*, or converted into the sound of *f;* as *daughter*, *laughter*.

The *French u* is perhaps peculiar to that nation. If this be true; the words, in which it is found, when transferred to another language, will always assume a new pronunciation. The same may be said of their *nasal m*, and *n*.

A perfect alphabet, if we exclude the *French nasal m*, and *n*, contains 44 letters; if we include them, 46. These, distributed, in a natural order, are the following.

	Rough.				Middle.			Smooth.
Loud.	Be.	Pe.	Low.	Loud.	eth.	eth.	Low.	L. el.
	De.	Te.			ev.	ef.		M. em.
	Ga.	Ka.			ez.	es.		N. en.
	Je.	Che.			ej French.	esh.		NG. eng.
								R. Smooth.
								R. Rough.

Aspirates. H. he.
X. chi. Greek.

Vowels.

a in face,
in bat,
in barn.
e in fleece,
bet,
berm.
in fine,
fit,
ir.
o in bone,
home,
bott,
born.
oo in boot,
bush.
u in Bruce,
but,
burn.
u French.
u Indescribable.

Consonants.

Rough	8
Middle	8
Smoot	6
Aspirates	
	24
Vowels	20
	44

Of these, all are found in the pronunciation of the *English* language, except the two last *u's*, and the Greek *X*, or the rough aspirate. The *French j* is sounded in *vision*, and other similar words.

The alphabet, said to have been brought by *Cadmus* into *Greece*, consisted of 16 letters.

From a comparison of these alphabets it will be seen, that, although that of *Cadmus* may, by making one letter the representative of more sounds than one, have been considerably enlarged in its actual effect, yet it must have been comparatively limited. The pronunciation of all languages, and dialects, is of course restricted to the number of letters, actually in use. These, compared with a perfect alphabet, are, perhaps always, defective in the number of their sounds; and most of them to a considerable degree. Wherever this is the case; a nation will be unable to pronounce those sounds in other languages, with respect to which its own language is defective. As many alphabets are seriously defective; this fact will produce, in the end, a great diversity of pronunciation. In one nation several sounds will be used, which are omitted by another; and several will be omitted, which are used by that other.

The *Commutation of letters* is another source of changes. The Germans use *d* where the English use *t;* and *b*, where the English use *p;* and *vice versa.* Thus they say *dumplers* where the English say *tumblers.* Commutations of this nature, as actually existing in the several nations of mankind, are considerably numerous; and have a considerable influence in varying pronunciation. The *Romans*, in transferring words from the Greek language into their own, changed

B into P, e. g. Βοσκω into *Pasco,*
F, Βρεμω into *Fremo,*
and V, Γιλβος into *Gilvus.*

They also inverted this order of mutation.

The *Greeks*, in making the same transferrence, changed the Roman

C into Γ: e. g. *Caius* into Γαιος.

The Romans themselves anciently wrote

C for *G:* e. g. *Acnom* for *Agnum*, and *Pucno* for *Pugno.*

T

In a similar manner they changed

D into *T*; and *vice versa*.

Anciently, *D* was written for *L*, as *Sedda* for *Sella*, and *dingua* for *lingua*. It was also written for Θ, as *Ador* for Αθηρ.

The *Latin E* was changed into all the other vowels.

F was anciently written by the *Romans* for *H*, as *Fordeum* for *Hordeum*.

G was changed into *C*, and into *Z*; and

I into *U*, as *optumus* into *optimus*; and also into *E*, and *vice versa*.

L was sometimes changed into *N*, and sometimes into *D*.

The mutual commutations of *M* and *N* are too well known to be insisted on here.

It is also well known, that

N was sometimes changed into *L*, and sometimes into *R*.

O and *U* were frequently written for each other.

P was changed into *F* and *V*, Γ and *K*.

V was changed into *B* and *P*;

U into all the vowels; and

Ionic.
Z into *G*, as ολιζον for ολιγον.
Doric.
ζευω for γευω.

From these changes, which might be pursued to a greater extent, and of which many more examples might be given, it is evident, that language may, and in many instances must, have been so greatly altered, from this source alone, as to become unintelligible to those, by whom the changes had not been made.

This, however, was not the whole amount of these alterations. *Words were often written*, and by the *Greeks* generally, *in such a manner, as to make them accordant with the genius of the language, into which they were transferred*. Thus *Ormuzd*, *Mithr*, and *Ahriman*, the names of the *Persian Triad*, were written by the Greeks *Oromasdes*, *Mithras*, and *Arimanios*; *Khosrau*, or *Caikhosrau*, Κυρος, and by us *Cyrus*; *Cambakhsh*, *Cambyses*; and *Shiruyi*, or perhaps *Shirshah*, *Xerxes*. Let this change of mere writing be carried through a language; and it will become a new one at once.

It would be a curious, and not uninstructive, employment, *to trace the progress of words through the various deflections, produced by changes in the mode of writing merely;* and that in cases, where the original is all along perfectly known. I have no sufficient means of extending this kind of research far. The few following instances, may not, however, be without their use.

Examples of the different modes, in which the following words in the Hebrew language were written in kindred dialects.

Dialects.	*Father.*	*Heaven.*	*Earth.*	*Bread.*
Hebrew,	Ab.	Schamaim.	Arez.	Lechem.
Rabinical,	Av.	Idem.	Aretz.	Idem.
Chaldaic,	Abba.	Schmaja.	Ara.	Lahkma.
Samaritan,	Ab.	Schamaim.	Aretz.	Lechem.
Syriac,	Aboh.	Schmajo.	Arho.	Lachmo.
Arabic,	Aba.	Ssemavati.	Ardhi.	
Vulgar Arabic,	Abu.	Ssamvat.	Ardh.	
Malay, Bengalee,	Bappa.			
Ethiopic,	Abi.	Samai.	Myrdmi.	
Amharic,	Aba.	Ssamai.	Myrdrm.	
Shilhic,	Baba.			
Rhætic,	Bap, Pap.			
Sardic.	Babbu.			
Charaibic,	Baba.			

Examples of such words, derived from the Greek and Latin.

	Father.	*Heaven.*	*Earth.*	*Bread.*
Greek,	Πατηρ.			
Latin,	Pater.	Cœlum.	Terra.	Panis.
French,	Pere.	Ciel.	Terre.	Pain.
Italian,	Padre,	Cielo.	Terra.	Pane.
Sardian,	Pare.	Quelo.	Id.	Pa.
Spanish,	Padre,	Cielo.	Tierra.	Pan.
Catalonian,	Pare.	Cel.	Terra.	Pa.
Portuguese,	Pae, Pay.	Ceo.	Terra.	Pao.
Scotch,	Fāther.	British,	Dhayar.	
English,	Father.	Welsh,	Izer.	Pæne.
Runic,	Fader.			

Dialects.	*Father.*
Anglo-Saxon,	Fæder, Fader.
German,	Fater, Fatter. Bater, Batter.
Belgian,	Vader.
Dutch,	Vader.
Orkney,	Favor.

From the Teutonic.

	Heaven.	*Earth.*	*Bread.*
Gothic,	Himina.	Airthai.	Hlaif.
Runic,	Himium.	Jordaune.	Brodh.
Anglo-Saxon,	Hofenum, Heofnas, Heofunum.	Eorthan, Eortho, Eorthe, Heortho.	Hlaf.
Franc,	Himili.	Erdu.	Zuthi.
Allemanic,	Himile.	Erdo.	Brot.
German,	Hymel, Hemmal, Hemmele.	Erd, Earda.	Brot, Brodt, Braud, Brod.
Belgic,	Emelrike, Hemel.	Erdrike, Aerd.	Broet, Broot.
Frisian,	Hymil. Hiemmel.	Urtricke, Jorde.	Brae. Breea.
Icelandic,	Himne.	Jorde.	Braud.
Danish,	Himmel.	Jorde.	Brod.
Swedish and Norwegian,	Himmel.	Jorden.	Brod, Brouta.
English,	Heaven.	Earth.	Bread.

From the Sclavonian.

	Father.	*Heaven.*	*Earth.*	*Bread.*
Sclavonian,	Ottse.	Nebu.	Zemlyi.	Kruka.
Russian,	Otshe.	Nebesi.	Zemli.	Kleb.
Bohemian,	Ottse.	Nebi.	Zemi.	Hleb.
Dalmatian,	Otse.	Nebu.	Zemlyi.	Kruh.
Croatian,	Otse.	Nibeszih.	Zemli.	Hlib.
Vandalian,	Wotz, Woschzi.	Nebui, Nebu.	Semi, Zemi.	Chlieb, Kleb.
Bulgarian,	Otskye.	Nebu.	Zemli.	Kruh.
Nova-Zemblian,	Otcse.	Nebezi.	Zemli.	Klyb.
Servian,	Otse.	Nabeszih.	Zemli.	Hlib.
Carniolic,	Otze.	Nebeszih.	Zemlyi.	Krah.
Lusatian,	Voshe.	Nebie,	Zemie,	Klib.
Livonian,	Tabes.	Debbes.	Summes.	Mayse.
Polish,	Oycze.	Niebe.	Ziemi.	Chleb.

Names.

	James.
Hebrew,	Yakob.
Greek,	Ιακωβος.
Latin,	Jacobus.
French,	Jacques.
English,	James.
Italian,	Giacomo.
Spanish,	Iago.
Abyssinian,	Yagoube.

	John.
Hebrew,	Johanan.
Greek,	Ιωαννης.
Latin,	Johannes.
French,	Jean.
English,	John.
Dutch, vulgar,	Hans.
Italian,	Giovanni.
Spanish,	Juan.

A fourth cause of changes in Language, is found in *the State of Society.*

It must, I think, be admitted, that, if a nation, or perhaps as a better example, a tribe, were to continue for many ages in the same spot, where the same natural objects were presented to every succeeding generation; in the same state of manners, laws, and religion; and, universally, were to be possessed of the same ideas, and the same occasions to communicate them; *they would keep their language unaltered.* But, with every change in society, an alteration in their language will take place. This part of the subject has been, to some extent, illustrated in laying down the scheme, at the commencement of these observations. I will attempt further to illustrate it in the following manner.

Suppose a ship, from a country in a state of complete civilization, containing a numerous body of passengers; men, women, and children; to be wrecked on an uninhabited shore; and these people enabled to find sufficient subsistence, and to inhabit the country, through an indefinite series of generations. What effects would these events produce on their language? A satisfactory answer to these enquiries will be found in the following observations.

1*st. They would in a short time lose a great part of their language.*

It has been observed above, that men have those words in their customary speech, which express such ideas, as they have occasion to communicate; and no other. These people, being without books, and metals, would soon lose their knowledge, arts, and civilization; and with them the great mass of their ideas. In other words, they would become, in a moderate number of years, absolute savages. With these ideas, they would of course lose the words, by which they were denoted. Particularly, they would lose the names of all the parts, and of all the furniture, of a house, except such as were retained in a *weekwam;* of all the utensils, and of all the parts of dress, except such as are used by *Indians;* and of all employments, beside such, as *Indians* pursue. Out of their language would vanish the terms, which belong to agricultural, mechanical, and manufacturing, business; to navigation, and commerce; to the science, and business, of government; and to the liberal arts, and sciences; the greater part of those words, which pertain to religion, and morals; and to decency, and refinement of manners. Universally, they would lose almost all those words, which denote ideas, formed by composition, abstraction, and comparison. But these various sorts of words constitute almost the whole language of a civilized people.

They would also lose the names of those natural objects, presented to them in the country, whence the colony emigrated, and not found in their present residence.

2dly. *At the same time, they would form new words, to express such natural objects, as were different from those, which they had known before, and such employments as were new to them; and, universally, for such new ideas, as they had occasion to communicate.* These, however, would be few.

Thus their language would by this cause become greatly changed. Most of it would vanish: a part would be retained; and a part would be new.

Among the words, which they retained, would in all probability be found *the names of near, and important, natural relations;* as father, mother, brother, sister, &c.; *the personal pronouns; the names of the most common natural objects, and of the most familiar, and important, actions.* The *Mohekaneews* have the same personal pronouns with those of the Hebrew language; and in all probability derived them, at some period or other in the history of man, from that language: such a fact being hardly attributable to chance.

What would be true concerning persons, thus shipwrecked, must be equally true concerning a body of people, separated from a civilized stock, and wandering into a wilderness so far, as to lose their intercourse with that stock. All the effects produced on the state of society in the case, which I have supposed, would be effected here. Such a colony would lose, ordinarily, the the knowledge of the metals, and of course the employments, and ideas, to which they gave birth. Of civilized men they would speedily become savages; and would sink their pastoral, agricultural, and commercial employments, in hunting, fishing, and war. Of course, their language would change in the very manner, which is here supposed.

The colonies, which emigrated from the family of *Noah*, were some of them very differently situated from others, with respect to the principal subject of this discourse. Some of these carried with them all their arts and civilization; and of course their language; that is, chiefly. Others speedily became mere savages, and hunters; and were the first among mankind, who sustained this character: there being no reason to suspect, that such a state of society, as is usually denominated the hunting, or savage, state, existed among the antediluvians. The language of these colonies underwent the very changes, which have been mentioned above, in the case of the supposed *shipwreck*. Other colonies, still, in various degrees lost more of their civilization than the former, and less than the latter, of the classes, already specified. These retained their language in different degrees. As these several colonies settled in very different countries, and climates, where different sets of objects were presented to their view; as in these countries they pursued very different employments, and had occasion to communicate very different ideas; the parts of their languages, which were new, must have been very different. In some instances they must have been almost wholly unlike; in others very similar.

Should we now suppose the descendants of this shipwrecked company, or of one of these colonies, which had fallen into a state of barbarism, to emerge again into a state of civilization, and science: Their language, thus changed, and thus barren, would in an inverse order undergo another change, equally great; as their ideas, particularly those derived from composition, abstraction, and comparison, would be greatly multiplied; those, I mean, which they would wish to communicate: and for all these, words would be devised. Should they derive their improvements from the books of another nation; these words would extensively be taken from the language of that nation: and this seems to have been the only course of mankind, in their progress out of the savage and civilized states. In this view of the subject it is perfectly evident, that, *in consequence of these two great revolutions, their language would become in a great measure new.*

A fifth cause of changes in language is found in *Intercourse with other nations.* Persons, who have much intercourse with each other, always become acquainted in some measure with each other's language. Of these, a few, comparatively, will learn the respective languages well, and will keep them distinct. The many will acquire them imperfectly; pronounce them badly; and mingle them together. The words of one language, however, will in all such cases be transferred to the other.

The most remarkable example of a mixed language, springing from such intercourse, of which I have heard, is *the lingua Franca.* This, as I understand, is a medley of various languages, spoken by no nation in the world; understood by no nation; and accordant with no grammatical analogy, or legitimate pronunciation. Yet it is spoken, and understood, on the borders of the *Mediterranean*, by such inhabitants of different countries, as live in trading towns on the shore, and have intercourse with its several nations. A more striking proof cannot be wished, that mankind will always conform their speech to the exigencies of life.

It ought to be observed, that, when words are from this cause transferred from one language to another, they are generally made to follow the analogy of the language, in which they are interwoven; yet not so absolutely, as to prevent them, if considerably numerous, from increasing its anomalies.

The sixth and last cause of such changes, which I shall mention, *is Conquest.*

Mankind have been almost ever at war; and conquests have been made in every spot on the globe. Where-ever the conquerors have continued for a length of time, and established their domininion, they have introduced a material change into the language of the conquered. The *Romans* spread their language over their whole empire; and made it the written language of all their western, northern, and of nearly all their southern, provinces. The *Saxons* in a great measure exterminated the language, spoken in *England* before their arrival; and made their own tongue the principal source of the present *English.* *Canute* introduced a number of *Danish* words. *William*, the *Norman*, sprinkled the language with *French* words: and thus have other conquerors affected the languages of the countries, which they subdued.

In conquered countries, the laws, and legal processes, being uttered, and directed, by the conquerors, will usually be in their language. The knowledge, and use, of this language, must in a considerable degree, therefore, be indispensable to the comfort, and even to the safety, of the conquered. Hence it will be extensively learned by them. Multitudes will also acquire it from fashion; from a desire to resemble their rulers; from the hope of being employed in departments of the government; from the prospect of obtaining lucrative business; and from various other motives. When conquerors have ruled, for a great length of time; the changes, wrought in language by their influence, become permanent; and the language will never return to its original state. The *Shanscrit* is now a learned language in *Hindoostan*; and even the Bengalee, which seems to have followed it in the country of *Bengal*, sustains this character in a considerable degree. In the *Lowlands* of *Scotland*, the

English, introduced by conquest, has chiefly supplanted the *Gaëlic;* and has retained its place, in a dialectic form, down to the present time.

There is one subject, of considerable importance in this investigation, which has scarcely been touched in the course of these remarks. This is *the diversity of the manner, in which languages are constructed.* The things, in which, so far as my knowledge extends, this diversity has been most conspicuous, are *the variations of meaning by prefixes, and suffixes ;* and *the expression of relations*, on the one hand, *by terminations of nouns*, and, on the other, by *prepositions ;* and *the conveyance of diversities of Action*, in some languages by *the various endings of verbs*, and in others by *auxiliaries.* Of the first of these it will be unnecessary, here, to say any more, than that it existed, not only in the Hebrew, but in the language of the *Mohekaneews*, that of the *Araucanians*, and, if I mistake not, a number of others. With respect to the diversity in the last cases mentioned, it is well known, that the *Greek* and *Roman* languages depended, to a great extent, for the expression of relations, on the terminations of their nouns, and of the shades of action on those of their verbs; and that the modern languages of *Europe* denote, chiefly, the former by prepositions, and the latter by auxiliaries.

Concerning this subject, I observe in the first place, that *the use of auxiliaries seems chiefly to have been a modern invention.* The *Greeks* used the substantive verb, in a very small degree, as an auxiliary. The *Romans* adopted this form of phraseology more extensively: but neither of these nations had any other auxiliary; and in the use of this, both were comparatively confined. In the *English* language *there are no less than eight auxiliary verbs; and these are combined in a prodigious variety of forms.* But *neither of the languages*, from which the *English* is derived, was constructed in this manner. The *Roman*, and to a considerable degree the *Saxon*, depended on terminations to express the relations, and variations, of thought. We have not, therefore, followed the analogy of either of the parent languages; but have created a new one, and that, independently of the anomalies, with which our language has been disturbed by the confluence, and mixture, of many streams. Most of the modern languages of *Europe* have followed the same course. The effect, therefore, seems to have flowed from a cause, common to all the nations, by which these are spoken.

Secondly. *It is admitted on all hands, that the second of these modes is the most favourable to Perspicuity; and the first, to Impression.* The *Romans*, and *Greeks*, were unquestionably far more solicitous than we are to make deep impressions on those, to whom they wrote, or spoke; and far less, to communicate clear and distinct ideas. For the former of these purposes *their* languages were more fitted, and for the latter much less, than *ours*. The *English* Verb, particularly, is by its auxiliaries moulded into a wonderful variety of forms: all of them adopted, to express real varieties of existence, and action; and all of them actually expressing these varieties. The *English Active Verb*, in the first person, and indicative mode, is varied through *fourteen forms*: all of them expressing different shades of thought. The *Latin Verb*, in the same circumstances, has only *five forms*; and the *Greek*, *eight: three of them* superfluous, and useless, or very nearly so. The *English Potential Mode* is probably a peculiarity, and the greatest ornament, of our language; expressing shades of thought, of vast importance to minds of superior intelligence, and incapable of being expressed, even in circumlocutory phraseology, by either the Latin, or the Greek. Much less were they expressible by the variations of the Verb in these languages. It is hardly necessary to observe that neither of these languages had a *potential mode*. The *Greeks* had an *Optative*; but it was of very little significance, and very little use. The potential mode in the English is indispensable to exact and superior ratiocination. The forms of the verb in this mode amount to no less than 32.

The forms in the *Subjunctive*, every one of which has its use, are equal in number to those in both the preceding modes: viz. 46.

This example shews, in the strongest possible manner, the unrivalled attention, paid by the *English* nation to exactness of thought, and to perspicuity, and precision, of language.

The number of *Prepositions* in our language is much greater than that, in both the *Latin* and *Greek* tongues. I do not know this number exactly; but it is not far from *fifty*. As the whole use of prepositions is to express with exactness the relations between objects; this multiplication of them is another remarkable proof of the same attention, on the part of those, by whom it is spoken.

Both the *Greeks* and *Romans* were sensible of the imperfection, with which relations were expressed by the terminations of their *Nouns;* and therefore adopted a considerable number of prepositions, to aid themselves in expressing these relations more perfectly. But this imperfection is much more strongly visible in a single example. By *the ablative case* in the Latin language were customarily denoted the several relations, which we express by the prepositions *at*, *by*, *from*, *in*, *on*, *with*. What a degree of ambiguity is involved in this single fact: especially when we remember, that it is applicable to every noun: and how perfectly is this ambiguity precluded by the use of these prepositions? I know there are men, who, either from taste or the affectation of it, or from the preference of impression to truth, would willingly decline the advantages, accruing from this and other similar sources to the intellect; and rest satisfied with the superiour neatness of a language, resting its meaning on terminations. With these men I shall not enter into a controversy; but shall content myself with merely saying, that, in my own view, reason is more valuable than passion and imagination; clearness of thought, than impression; and perspicuity and precision of style, than beauty.

The vast multiplication of *Conjunctions* in our language, for the purpose of expressing with exactness the connections, and dependencies, of thought, is another proof, that the same object was strongly in view; and a part of the same design. These, if I mistake not, are more numerous in our language than in both of the others.

For these reasons it seems probable, that *this change* *of Construction* was derived from design; not indeed a design, systematically examined, and adopted, but forced upon the mind by its circumstances; peculiarly by the necessity, which was generally felt, of communicating truth, and of devising the modes, by which it might be exactly distinguished.

Having now, in some measure, shewn how languages are varied, both as to their terms, and their construction; it only remains to enquire *how many languages, radically distinct, there are in the world.* This enquiry is not intended to elicit any other than a loose, indefinite answer; which is plainly the only one, capable of being given. Yet this, perhaps, may be so given, as to induce a belief, that the whole number is incomparably less than has been generally thought.

In *Europe* there seem originally to have been but three distinct languages: the *Celtic*, the *Teutonic*, and the *Sclavonian.* The *Greek* and *Latin* languages appear, evidently, to be mixed, and not original. The *Greek* contains many *Celtic* words: and the original inhabitants of Greece were, I think, very evidently of the Celtic family. Their language was first mixed by the arrival of strangers from *Egypt*, and *Phœnicia:* chiefly, as I believe, *Cushite shepherds.* The *Latin* was partly *Celtic;* this being the language, spoken by the first inhabitants of *Italy;* and partly a corrupted *Greek*, derived from the colonies of that nation, which settled in *Magna Græcia.*

In *Asia* there were originally the *Hebrew*, and its dialects; the *Arabic*, the *Syriac*, and the *Chaldee;* the original *Persian;* the same, according to the evidence, exhibited by Sir William Jones, with the *Shanscrit;* the *Malayan;* the *Tatar;* at first probably the same throughout all the countries in the north of Asia; and perhaps the *Chinese;* not improbably derived from the *Tatar*, and mixed. The *Malayan* seems to be the radical language of most of the Islands. The original languages of *Egypt* and *Abyssinia* were, I think, evidently dialects of the *Hebrew;* or, perhaps more properly, the *Hebrew itself*, and *all its kindred tongues*, were *dialects of the one Original tongue*, spoken by *Noah, and his family.*

The languages of *Barbary* have in them nothing original. Those, spoken in the African countries, south of Barbary, are so little known, that nothing can be asserted concerning them. From analogy, I suspect, it will be found, that they are not very numerous.

In *North-America*, that of the *Iroquois*, that of the *Mohekaneews*, that of the *Choctaws*, and the three or four languages of *Mexico*, seem to be pretty well distinguished. In *South-America*, the *Peruvian*, the *Araucanian*, some languages in *Brazil*, that of the *Charaibes*, and perhaps one or more in *Terra Firma*, and one or more in *Patagonia*, are probably not far from the whole number. So far as this representation may be admitted as just, it will be seen, that the number of languages is not very great. There are, undoubtedly, more than these: some, spoken in *New-Holland;* some, in *Amazonia*, &c. Yet, after all allowances, the number, it is believed, will be comparatively small.

Travellers, and other persons, have, it seems to me, been accustomed to multiply the languages of mankind upon slender evidence. It is not long since, that many languages were supposed to be spoken in *New England.* It is now ascertained, that there was but one: that of the *Mohekaneews.* This, as it appears, was the language of all the tribes, the *Iroquois* excepted, between the *Atlantic* and the *Missisippi*, the *Potomac* and the *St. Lawrence.* It is also proved to be spoken by various tribes beyond the *Missisippi;* and by one within 400 miles of the *Pacific Ocean.*

I shall now leave it to the judgment of the reader to determine whether the causes, which have been here assigned, will not, to a considerable extent, account for the variety of languages, both in terms, and construction, so far as their state has been hitherto known.

No. XXIV.

ON

LIGHT.

To the Secretary of the
Connecticut Academy of Arts and Sciences.

SIR,

It is known to most of the gentlemen, who usually assemble at our meetings, that my eyes have long been weak. In some respects, the disease, with which they are affected, is perhaps peculiar. At least I have never seen some of the effects, which it produces, described in any publication. As they seem to me to elucidate, in a degree, the nature of light; I beg leave, through yonr good offices, to communicate this paper to the Academy.

The disease, whatever else may be its nature, appears to consist, partly, in an uncommon irritability of the optic nerve, and a consequent, uncommon susceptibility of impressions from light; and partly, of a relaxation, and enlargement, of the lymphatic vessels. Whether my views of the disease are just, or not, I am not desirous to determine: with regard to its effects, I cannot mistake. Among them this is one; that at all times, when it is dark, whether my eyes be closed or not, *light, distributed into innumerable little stars, or sparks, is seen floating over the field of vision in a great variety of directions.* In the appearance of these luminous points *there is little regularity.* They become visible, and disappear, in many instances, almost in the same spot. In many others, they move over a considerable distance, before they vanish. The most general, and that, which approaches nearest to a regular, motion, is from the upper, towards the lower, limit of vision. These stars appear in succession, whenever I am surrounded by darkness, whether in a dark room in the day time, or in the darkness of the night. Their existence I attribute to the *vascular circulation.* This, if I conjecture right, occasions in my eyes *an unnatural, and excessive, pressure upon the optic nerve.*

Whenever my eyes feel crowded, (a sensation, perfectly distinguishable, particularly from the frequent repetition of it at intervals, in some degree regular;) around the centre of vision *flashes of light, distantly resembling what is called a glory, but with little regularity of form,* take the place of these luminous points; and succeed each other with a considerable degree of rapidity. When I am in bed, and lie upon my back; they become intense, and vivid. If I turn upon my side, the brilliancy begins immediately to lessen, and after some time fades chiefly away. These appearances I attribute to an increased pressure, in both cases, upon the optic nerve. This pressure I suppose to be greatest, when I lie upon my back, and to produce the peculiar splendour of the flashes, at that time. When I lie upon my side, and my eyes are in a horizontal position; I suppose the pressure to be less, and the splendour for this reason to be diminished.

In many instances also, when my eyes are less crowded, *luminous clouds;* (phraseology, which better accords with the appearances, than any other, that I can think of;) commencing near the exteriour limit of vision, and irregular in their form, but filling up almost the whole field, contract themselves with considerable rapidity toward the centre, and there vanish. Their colour, towards the exteriour limit, is very frequently a reddish brown. As they advance inward, it becomes a strong *Saxon blue;* and in the end *a green,* which is often vivid. Of these clouds, floating inward, lessening, and vanishing, there is, in such cases, an uninterrupted succession. Their luminous appearance I attribute to an unnatural degree of pressure. Of their figure, and motion, I am unable to assign the causes.

Whenever it is dark; if I turn my eyes suddenly to the right, and left; on the side of each, opposite to that, towards which I turn them, there is formed *a sudden,* *and brilliant, circlet of light; somewhat irregular, and a little yellower than that of the sun.* This fact I attribute to the *increased* pressure on this part of both eyes.

All persons, who look at the sun, will perceive a bright image of this luminary, remaining in their eyes after they are turned away; more vivid, when the eyelids are shut; less, and less, when they are open. Persons, who have weak eyes, will derive this image from objects, which are in a moderate degree luminous; and will perceive it much longer, than those, whose eyes are not impaired. On my own such an image is impressed by every thing, which has any lustre; and, when they are most diseased, by every thing, which is of a light colour. When the image is vivid; it continues several minutes; but becomes gradually fainter, until it disappears. If, during the progress of its decay, I close my eyelids so, as to press them somewhat hardly; the image always becomes somewhat brighter, than it was immediately before. When this pressure is removed; it immediately becomes fainter.

From the uneasiness, which this disease very often occasions, I have not unfrequently been induced to press my eyes with my fingers. When the pressure reaches to a certain degree; *the whole field of vision becomes instantaneously luminous and bright; resembling in appearance a circular, polished plate of silver; covered with small drops of water, glittering with its lustre.* If these drops should be supposed suddenly to rise from behind the plate, and to move on its surface with rapidity, and without much regularity, the resemblance will, I think, be nearly complete. Sometimes I have increased the pressure beyond this degree. In this case, the drops of light have immediately disappeared; and *the field of vision has assumed exactly the aspect of the sun;* circular in its figure; uniform in its appearance; equally bright; and the light exactly of the same hue.

In some of these instances I have brought my finger suddenly, and carelessly, against the ball of the eye. In consequence of the pressure, produced in these cases, *a flood of light has instantaneously overspread the field of vision; exhibiting all the colours of the rainbow, not* *less distinct, nor less vivid, than those of the prismatic image.*

At times, the disease, which has been so often referred to, is attended with peculiar affections, arising from an unnatural accumulation of lymph, or some other fluid, either above, or on the left side, of my left eye. Among these affections are the following.

At times, *a bright spot, irregular in its figure, and like the sun in its lustre, and hue,* appears in the field of vision; brilliant even in the day time for a considerable period, in each instance; *uniform* in its aspect; and lasting from a quarter of an hour to two hours. In many instances these spots have, during a part of the process, lost their lustre, and suddenly become black. The lustre of the spots I attribute to an unnatural pressure on a part of the optic nerve; the blackness, to an increase of that pressure, so great, as to interrupt for a season the sensibility of the nerve in that place.

When the disease in this form has reached the utmost height, which I have experienced; *the field of vision has been crowded with lucid appearances, sometimes fixed, and sometimes moving.* They have also been of different forms. Those, which were fixed, have resembled a confused collection of pieces of white glass, or rock crystal, cut in the form of parallelopipedons, bevilled on both sides, and at both ends; and then held up to a sky light. In several instances I have almost lost my sight, when this affection has become intense; and supposed myself on the verge of an apoplectic fit. But, in every case, vigorous exercise has in a short time dispersed these unpleasant symptoms. This effect I attribute to the mere increase of the circulation.

The facts, already mentioned, may be sufficient to warrant the following conclusions.

1st. *All the appearances, denoted by the word,* VISIBLE, *are inherent in the nature of the Optic nerve; and not in the nature of light; nor in the nature of the objects, by which* IT IS TRANSMITTED TO THE EYE. We are prone, if I mistake not, to suppose, that there is a lustre in the element of light; that it is coloured with seven distinct hues; and that it diffuses over the face of nature the fine tints, which in an infinite variety adorn the universe around us. This, at least, has been the current of my own apprehensions. But from the facts, which have been recited, it is certain, that the splendour, and the colours, which we attribute to light, are the result of mere pressure. But there are neither colours, nor splendour, in pressure; nor in the finger, from which it proceeds. These extraordinary, and delightful, phenomena have their seat in the optic nerve; and exist in all their diversities, only as effects of the variations of pressure. Light itself has no more brilliancy than the finger. Its whole power is merely that of *gentle, and imperceptible, pressure*, or *impact, upon the optic nerve:* and this pressure, like that of the disease, and like that of the finger, awakens in the nerve the sensation of luminousness.

2dly. *Light is matter, and not a Quality of matter.* No degree, or kind, of impulse, whether such as we call pressure, or any other, can possibly be the effect of any *mere quality.* Both weight, and motion, are indispensable to its existence. Motion and weight, therefore, are certainly attributes of light.

3dly. *The Colours of light are the result of nothing, but different degrees of pressure, and impulse.* The colours, mentioned as seen in the case, specified above, were exactly the same with those of the prismatic image; equally bright; and, of course, sensibly brighter than those of the rainbow. In this case they were certainly derived from different degrees of pressure. There is not the least reason for attributing the effect to any thing else, when these colours are seen in the prism, or the rainbow. As the three strongest colours are less easy, and, when viewed for some time, more painful, than the other four; it is probable, that they are produced by a stronger impulse, or greater pressure.

4thly. *This difference of impulse can be derived from nothing, but the weight, or in other words the mass of matter, and the velocity, or both, of the particles of light.* As they come to us from the sun, perfectly, or almost perfectly, blended; (there being, for some reason or other, a small predominance of the yellow;) it seems probable, that their velocity is the same. Otherwise, it will be difficult to explain why every pencil of rays is not in some degree particoloured; at least momentarily. I should, therefore, incline to the opinion, that the rays, which produce the different impressions of colour, differ in their weight.

If I mistake not, the facts, which I have mentioned above, all lend their influence, with some diversity indeed, to the support of these positions.

I am, Sir, yours, &c.

T. DWIGHT.

No. XXV.

DEMONSTRATIONS

OF

STEWART's PROPERTIES

OF THE

CIRCLE.

By THEODORE STRONG,
Professor of Mathematics and Natural Philosophy in Hamilton College.

THE following propositions are to be found in Dr. Rees' Cyclopædia, under the article "*Circle.*" They were proposed to me for solution. Having examined and found them to be very curious, and connected by one general principle, I have, with a view of contributing my mite to the advancement of science, thought proper to communicate the following demonstrations of them to the Academy. I have succeeded in demonstrating them in three ways, which are different from the one here exhibited; one of which, being founded upon the principle of finding the sum of any powers of the chords and versed sines of arches of the Circle increasing arithmetically; together with many curious inferences deducible from the following demonstrations; I may hereafter take the liberty of communicating to the Academy. My only object, in the present communication, has been to demonstrate the propositions, as they were proposed in the aforesaid work.

THEODORE STRONG.

Hamilton College, Sept. 20th, 1814.

Lemma I.

IF the circumference of any circle be divided into any number of equal parts, and any point be taken in it; and if the several arches intercepted between the assumed point, and the points of division, reckoned around the circle in the same direction, be multiplied by any whole number, less than the number of the parts into which the circumference is divided; then, the extremities of these multiple arches will divide the circumference into equal parts.

DEMONSTRATION.

Let O (Plate III. Fig. 1.) be any circle, the circumference of which is divided into any number of equal parts, at the points a, b, c, &c.; and let any point, at A, be taken in the circumference, thus divided. Let P denote the circumference, and n, the number of the parts into which it is divided: then $\frac{P}{n} =$ any one of the parts.

Since Aa is such a part of $\frac{P}{n}$, as may be expressed by some fraction, let $\frac{r}{s}$ denote that fraction in its lowest terms: then Aa = $\frac{rP}{sn}$. Let $\frac{rP}{s}$ be denoted by Q: then, the arch Aa = $\frac{Q}{n}$; the arch Aab = $\frac{Q+P}{n}$; the arch Aabc = $\frac{Q+2P}{n}$, &c.; since the arches increase by the addition of $\frac{P}{n}$. Let the arches $\frac{Q}{n}$, $\frac{Q+P}{n}$, $\frac{Q+2P}{n}$, &c. be multiplied by any number m, less than n: then will they be represented by $\frac{mQ}{n}$, $\frac{mQ+mP}{n}$, $\frac{mQ+2mP}{n}$, &c.

Case I. Let the numbers m and n, have no common measure.

Set off from A, towards b, the arch AaB, equal to $\frac{mQ}{n}$; and from B, divide the circumference into as many equal parts as it was divided into at first.

Now, since the arch AaB, or its equal $\frac{mQ}{n}$, belongs to all the arches $\frac{mQ}{n}$, $\frac{mQ+mP}{n}$, $\frac{mQ+2mP}{n}$, &c.; if it be taken away from each of them, the remainders, o, $\frac{mP}{n}$, $\frac{2mP}{n}$, &c. will express the distances at which the aforesaid arches will respectively terminate, from B. Whence the first arch terminates at

B; and they will all terminate in the points at which the circumference was last equally divided; since m, $2m$, &c. are all whole numbers; and $\frac{P}{n}$ = one of the parts, into which the circumference was last divided.

Since m, and n, are prime to each other, and the several numbers 1, 2, 3, &c., until we come to n, are each less than n; it follows that $\frac{m}{n}$, $\frac{2m}{n}$, $\frac{3m}{n}$, &c., until we come to $\frac{nm}{n}$, cannot either of them be a whole number. Therefore, no one of the arches $\frac{mP}{n}$, $\frac{2mP}{n}$, &c., until we come to $\frac{nmP}{n}$, can terminate at the point B. It follows also, that these arches all terminate in different points; for in order that more than one of them should terminate at the same point, some one of them must have terminated at B; when the remaining arches would go on to terminate in the same points, at which those already taken had terminated respectively: (since they increase from B, by the common difference $\frac{mP}{n}$.) Therefore, since the arches o, $\frac{mP}{n}$, $\frac{2mP}{n}$, &c., and $\frac{mQ}{n}$, $\frac{mQ+mP}{n}$, $\frac{mQ+2mP}{n}$, &c., the former series reckoned from B, and the latter from A, do respectively terminate in the same points; and since the arches of the former series do respectively terminate at different points until we come to the arch $\frac{nmP}{n}$; and since they each terminate in some one of the points B, C, D, &c.; and since there are as many arches as points; it follows, that they divide the circumference into as many, and the same parts, as the points B, C, D, &c. divide it. But these points divide it by construction into n equal parts; therefore each series of arches, divides the circumference into n equal parts.

Case II. Let m and n have some common measure, and let t denote their greatest common measure; let $\frac{m}{n}$ be reduced to its lowest terms, by dividing m and n by t; and let $\frac{k}{g}$ denote the fraction thus reduced. Then will the arches $\frac{mQ}{n}$, $\frac{mQ+mP}{n}$, $\frac{mQ+2mP}{n}$, &c., be equal respectively to $\frac{kQ}{g}$, $\frac{kQ+kP}{g}$, $\frac{kQ+2kP}{g}$, &c.

Now, since the fraction $\frac{k}{g}$ is in its lowest terms, k and g are of course prime to each other. Therefore, taking the arch AaB $= \frac{kQ}{g}$, and supposing the circumference to be divided from B, into g equal parts; it may be shewn, as in Case I, that the arches $\frac{kQ}{g}$, $\frac{kQ+kP}{g}$, $\frac{kQ+2kP}{g}$, &c. will divide the circumference at the supposed points, into as many equal parts as there are units in g; when we have taken as many of them as there are units in g: and then the remaining arches will go on to terminate in the same points respectively, as those already taken, until as many are taken, in all, as there are units in $2g$; then the remainder will go on as before, until the number taken is equal to $3g$; and so on, until the number becomes equal to tg, or n. Q. E. D.

Cor. It appears from the demonstration, that when the numbers m and n are prime to each other, the multiple arches divide the circumference into as many equal parts as there are units in n: and that, when m and n are not prime to each other, if the fraction $\frac{m}{n}$, reduced to its lowest terms, be denominated by $\frac{k}{g}$, then the multiple arches divide the circumference into as many equal parts as there are units in g. And if t denote the greatest common measure of the terms of the fraction $\frac{m}{n}$, the number of arches which terminate in each point of division, will be equal to t.

Lemma II.

IF, in the circumference of any circle, there be taken three arches, which have equal differences; it will be, As the diameter, is to the supplementary chord of their common difference; so is the chord of the mean arch, to half the sum of the chords of the extreme arches.

DEMONSTRATION.

Let O (Plate III. Fig. 2.) be any circle; and in its circumference let there be taken any three equidifferent arches, as DK, EH, and FG, so situated that DE = KH, and EF = HG. Draw the chords DK, EH, and FG. From E draw the diameter EN.

Connect the points D and F, by the right line DF; K and G, by KG; and H and N, by HN. From the point L, where the diameter bisects DF, draw LM, parallel to EH or DK, or FG. From M, the point where LM intersects KG, draw MR, parallel to HN. Through F, draw FP, parallel to EN; and through P, the point where FP meets the circumference, draw PQ, parallel to FD.

Since DK and FG are parallel, and $DL = LF$, and LM is drawn parallel to DK and FG, it follows that $KM = MG$; whence $LM = \frac{DK+FG}{2}$. It is manifest also, from the construction, that the arch DEF is the common difference of the assumed arches, and that the line FP, parallel to EN, cuts off the arch FP equal to its supplement, since the angle DFP is a right angle. It is obvious also, that PQ, parallel to FD, meets the diameter EN, in the same point R, in which MR, parallel to HN, meets it. For, from the centre O, draw OT, perpendicular to LM. Since in the triangle LMR, OT is drawn parallel to one of its sides, LT : TM :: LO : OR. But $LT = TM$; therefore $LO = OR$; of course, $EL = NR$. But $EL = NQ$; wherefore $NR = NQ$.

Then in the similar triangles LMR, EHN, it will be, EN : (LR or) FP :: EH : (LM or) $\frac{DK+FG}{2}$. Q. E. D.

Corollary I. Hence the chord $FG = \frac{2FP \cdot EH}{EN} - DK = \frac{2FP \cdot EH - DK \cdot EN}{EN}$. In like manner, $DK = \frac{2FP \cdot EH - FG \cdot EN}{EN}$. Therefore, if the chord of the mean of three equidifferent arches, be multiplied by twice the supplementary chord of their common difference; and from their product, there be taken the product of the diameter and the chord of one of the extreme arches; and the difference be divided by the diameter; the quotient will express the chord of the other extreme arch.

Cor. II. Hence the chord of any multiple of an arch may be expressed, in terms of the chord of the arch; its supplementary chord; and the diameter.

Let the points D and K be supposed to coincide; and then let A denote the arch EDH. Then will the arch $FDG = 2A$. Whence the chord of $2A = \frac{2FP \cdot EH}{EN}$, which is the expression for the chord of the arch FDKG, when the arch $DK = o$.

In like manner, considering A, 2A, 3A, as the arches, the chord of $3A = \frac{\overline{2FP}^{2}\cdot EH - EH\cdot EN^{2}}{EN^{2}}$. In like manner, also, the chord of $4A = \frac{\overline{2FP}^{3}\cdot EH - 4FP\cdot EH\cdot EN^{2}}{EN^{3}}$.

In general, the chord of mA, will be equal to

$$\frac{\overline{2FP}^{m-1}\cdot EH - \frac{m-2}{1}\times\overline{2FP}^{m-3}\cdot EH\cdot EN^{2} + \frac{m-3}{1}\times\frac{m-4}{2}\times\overline{2FP}^{m-5}\cdot EH\cdot EN^{4} - \frac{m-4}{1}\times\frac{m-5}{2}\times\frac{m-6}{3}\times\overline{2FP}^{m-7}\cdot EH\cdot EN^{6} + \&c.}{EN^{m-1}}$$

; which, if FP be denoted by a; EH, by b; and EN, by d, will become, $b\times$

$$\frac{\overline{2a}^{m-1} - \frac{m-2}{1}\times\overline{2a}^{m-3}\cdot d^{2} + \frac{m-3}{1}\times\frac{m-4}{2}\times\overline{2a}^{m-5}\cdot d^{4} - \frac{m-4}{1}\times\frac{m-5}{2}\times\frac{m-6}{3}\times\overline{2a}^{m-7}\cdot d^{6} + \&c.}{d^{m-1}}$$

; and this series will terminate when the numerator of of one of the factors in the co-efficient of the power of $2a$ has become $m-m$.

Lemma III.

IF there be any regular figure circumscribed about a circle; and from any point within the figure, perpendiculars be drawn to all the sides of the figure; the sum of all the perpendiculars will be equal to the multiple of the radius of the circle, by the number of the sides of the figure.

DEMONSTRATION.

Let O (Plate III. Fig. 3) be any circle, and A, B, C, &c. any regular figure circumscribed about it. Let H be any point within the figure, and draw HI, HK, HP, &c. perpendicular to all the sides of the figure; and also draw the right lines HE, HF, HC, HB, &c to all the angular points of the figure. From O, the centre of the circle, draw OG, ON, &c. to all the points of contact, between the sides of the figure, and the circumference; and also, OE, OD, OA, &c. to all the angular points of the figure.

Now, the area of the triangle EHF $= \frac{HI\cdot EF}{2}$; and the area of FHC $= \frac{HK\cdot CF}{2}$; and so of all the other triangles, whose vertices are at H. But because the figure is regular, the bases

EF, CF, &c. are all equal. Therefore, the sum of the areas of all the triangles EHF, FHC, &c. will be equal to $\frac{EF}{2} \times \overline{HI+HK+\&c.}$ = area of the whole figure.

In like manner, the sum of all the triangles EOD, DOA, &c. whose vertices are at the centre O, is equal to $\frac{DE}{2} \times \overline{OG+ON+\&c.}$; since OG, ON, &c. are respectively perpendicular to the sides ED, DA, &c. But since OG, ON, &c. are all radii of the circle; their sum is equal to the radius, multiplied by the number of the sides of the figure. Therefore, the sum of all the triangles EOD, DOA, &c. $= \frac{DE}{2} \times$ Radius of the circle, $\times$ number of sides of the figure, = Area of the whole figure. But it was before shown, that $\frac{EF}{2} \times$ sum of all the perpendiculars from H = Area of the whole figure. Therefore, (since $\frac{DE}{2} = \frac{EF}{2}$,) the sum of all the perpendiculars from H = Radius of the circle, multiplied into the number of the sides of the figure. Q. E. D.

Note. If n denote the number of the sides of the figure; and R, the radius of the circle; then will the sum of the perpendiculars be equal to nR.

Lemma IV.

IF the circumference of any circle be divided into any number of equal parts; and if from any point in the circumference, right lines be drawn to all the points of division; the sum of the squares of all these lines will be equal to twice the square of the radius of the circle, multiplied by the number of the parts, into which the circumference is divided. Thus, if n denote the number of the parts; and R, the radius of the circle; the sum of the squares of the aforesaid lines, will be equal to $2nR^2$.

DEMONSTRATION.

Let O (Plate III. Fig. 4) be any circle, the circumference of which is divided into any number of equal parts, at the points

E, D, &c. Take A, any point in the circumference, and draw AE, AD, &c. to all the points of division. Draw the diameter AB; and from all the points E, D, &c. draw EM, DQ, &c. perpendicular to AB. At the points E, D, &c. draw also tangents to the circle; and from A, draw AS, AP, &c. perpendicular to all the tangents.

Since the angles at S and M are both right angles; and the $\angle AES = \angle AEM$; and AE is opposite the angles at S and M; therefore $AS = AM$. In like manner, $AP = AQ$. And in general, the perpendicular from A, to any tangent, is equal to the part of AB, intercepted between A, and the point where the perpendicular, let fall from the point of contact of the tangent, intersects AB.

Now $AE^2 = AB \cdot AM$; and $AD^2 = AB \cdot AQ$; and so of all the lines drawn from A to the points of division. Therefore, $AE^2 + AD^2 + \&c. = AB \cdot \overline{AM + AQ + \&c.} = AB \cdot \overline{AS + AP + \&c.}$ But (Lemma 3d.) $AS + AP + \&c. = nR$; since, if the tangents be extended, they will meet, and form a regular figure, circumscribed about the circle, in all cases, except when the circumference is divided into only two equal parts; in which case, the tangents being parallel, the sum of the perpendiculars will be manifestly equal to nR. Therefore, since $AB = 2R$; $AB \cdot \overline{AS + AP + \&c.} = AE^2 + AD^2 + \&c. = 2nR^2$. Q. E. D.

Cor. Hence, if the arches AE, AED, &c. be multiplied by any number $m \angle n$; the sum of the squares of all the lines drawn from A, to the points where the multiple arches divide the circumference, will be equal to $AE^2 + AD^2 + \&c. = 2nR^2$. For, (Lemma 1st.) the multiple arches, mAE, mAED, &c. divide the circumference into equal parts; the number of which, if m and n are prime to each other, is equal to the number of the parts into which the circumference was at first divided. But if m and n be not prime to each other, let the fraction $\frac{m}{n}$, when reduced to its lowest terms, by dividing m and n by t, its greatest common measure, be denoted by $\frac{k}{g}$. Then (Lemma 1st.) the arches mAE, mAED, &c. divide the circumference into as many equal parts, as there are units in g; and as many arches terminate in each point of division, as there are units in t.

Therefore, when m and n are prime to each other, the sum of the squares of all the lines drawn from A, to the points where the arches mAE, mAED, &c. terminate, will be equal to $2nR^2$.

And when m and n are not prime to each other, the sum of the squares of these lines will be equal to $2gR^2$. But each one of these lines is to be taken as many times as there are units in t; therefore the sum of the squares of the lines belonging to all the arches, will be equal to $2tgR^2=2nR^2$.

Proposition I.

LET there be any regular figure inscribed in a circle; and from all the angles of the figure, let there be drawn right lines to any point in the circumference of the circle: the sum of the fourth powers of the chords will be equal to six times the multiple of the fourth power of the radius of the circle, by the number of the sides of the figure.

Thus, if n denote the number of the sides of the figure, and R, the radius of the circle; the sum of the fourth powers of the chords will be equal to $6nR^4$.

DEMONSTRATION.

Let O (Plate III. Fig. 5) be any circle, and A, B, C, &c. the angular points of any regular figure, incribed within it. Let P be any point in the circumference; and let there be drawn to it, the right lines PC, PB, &c. from all the angular points of the figure.

It is evident, that the angular points of the figure, divide the circumference into equal parts, the number of which is equal to the number of the sides of the figure. Let now, the arches PC, PCB, &c. be multiplied by the number 2. Then (Lemma 1st.) the arches 2PC, 2PCB, &c. will divide the circumference into equal parts. And if right lines be drawn from P, to all the points where the multiple arches terminate; then (Coroll. Lemma 4.) the sum of the squares of the chords, belonging to all the arches, will be equal to $2nR^2$.

Draw through P, the diameter PQ; and from the points C, B, &c. draw CQ, BQ, &c. Then (Cor. Lemma 2d.) the chord of 2PC will be equal to $\frac{2QC\cdot PC}{PQ}$. But $2QC=2\sqrt{PQ^2-PC^2}$; and $PQ=2R$; and let the chord of the arch 2PC be denoted by x. Then $x=\frac{2PC\sqrt{4R^2-PC^2}}{2R}$. Hence $x^2=\frac{4R^2\cdot PC^2-PC^4}{R^2}$. And $x^2R^2=4R^2\cdot PC^2-PC^4$; or $PC^4=4R^2\cdot PC^2-x^2R^2$.

In like manner, if y denote the chord of the arch 2PCB, it may be shewn that $PB^4=4R^2\cdot PB^2-y^2R^2$. And so of all the rest. Therefore, PC^4+PB^4+ &c. $=4R^2\cdot PC^2+4R^2\cdot PB^2+$ &c. $-\overline{x^2R^2+y^2R^2+\&c.} = 4R^2\cdot\overline{PC^2+PB^2+\&c.}-R^2\cdot\overline{x^2+y^2+\&c.}$ But (Lemma 4th.) PC^2+PB^2+ &c. $=2nR^2$; and (as was shown above) x^2+y^2+ &c. $=2nR^2$. Therefore PC^4+PB^4+ &c. $=4R^2\cdot 2nR^2-R^2\cdot 2nR^2=8nR^4-2nR^4=6nR^4$. Q. E. D.

Cor. Hence, if any regular figure of a greater number of sides than three, be inscribed in a circle; and the same construction remain; the sum of the sixth powers of the chords PC, PB, &c. will be equal to $20nR^6$.

For, let the arches PC, PCB, &c. be multiplied by the number 3; and let the chords of the arches 3PC, 3PCB, &c. be denoted by d, e, &c. respectively. Then (by Cor. 2d. Lemma 2d.) the chord of the arch $3PC=d=\frac{\overline{2QC}^2\cdot PC-PC\cdot PQ^2}{PQ^2}$. Substituting for $\overline{2QC}^2$, and PQ^2, their respective values, $16R^2-4PC^2$, and $4R^2$; it becomes, $d=\frac{16R^2\cdot PC-4PC^3-4R^2\cdot PC}{4R^2}=\frac{12R^2\cdot PC-4PC^3}{4R^2}$. Hence $d^2=\frac{144R^4\cdot PC^2-96R^2\cdot PC^4+16PC^6}{16R^4}$; and $16d^2R^4=144R^4\cdot PC^2-96R^2\cdot PC^4+16PC^6$; or $9R^4\cdot PC^2-6R^2\cdot PC^4+PC^6=d^2R^2$; whence $PC^6=d^2R^4-9R^4\cdot PC^2+6R^2\cdot PC^4$.

In like manner, it may be shewn that $PB^6=e^2R^4-9R^4\cdot PB^2+6R^2\cdot PB^4$. And so of the chords of all the other arches.

Therefore, PC^6+PB^6+ &c. $=R^4\cdot\overline{d^2+e^2+\&c.}-9R^4\cdot\overline{PC^2+PB^2+\&c.}+6R^2\cdot\overline{PC^4+PB^4+\&c.}$ But (Cor. Lemma 4th.) d^2+e^2+ &c. $=2nR^2$; and PC^2+PB^2+ &c. $=2nR^2$: and (by the Proposition) PC^4+PB^4+ &c. $=6nR^4$. Therefore PC^6+PB^6+ &c. $=2nR^6-18nR^6+36nR^6=20nR^6$.

By the same process of reasoning, when the inscribed figure has more than four sides, it may be shown, that the sum of the eighth powers of the chords PC, PB, &c. is equal to $70nR^8$.

In general, let m be any number less than n; then will the sum of the $2m$th powers of the chords PC, PB, &c. be equal to $n \times \frac{1\cdot 3\cdot 5\cdot 7 \cdots\cdots 2m-1}{1\cdot 2\cdot 3\cdot 4 \cdots\cdots m} \times 2^m \cdot R^{2m}$; where the numbers 1, 3, 5, 7, &c. are to be continued until the last equals $2m-1$; and the numbers 1, 2, 3, 4, &c., until the last equals m.

Proposition II.

LET there be any regular figure inscribed in a circle; and from all the angles of the figure and the centre of the circle, let there be drawn right lines to any point: the sum of the fourth powers of the lines drawn from the angles of the figure, will be equal to the multiple, by the number of the sides of the figure, of the fourth power of the radius of the circle; together with four times the multiple by the same number, of the fourth power of the line whose square is equal to the rectangle contained by the radius, and the line drawn from the centre; together with the multiple by the same number, of the fourth power of the line drawn from the centre.

*DEMONSTRATION.**

Let O (Plate III. Fig. 6) be any circle, and A, B, C, &c. the angular points of any regular figure inscribed in it. Take any point, as P; and through P, and the centre, draw the diameter POQ, produced if necessary. Draw also PC, PB, &c. from all the angular points; and from C, B, &c. draw CG, BH, &c. perpendicular to the diameter.

When P is taken without the circle, let it be denoted by P'; and when within, by P''.

Now, because the angle CPP' is always obtuse, therefore $CP'^2 = P'P^2 + PC^2 + 2P'P \cdot PG$. And because the angle CPP'' is always acute, therefore $CP''^2 = P''P^2 + PC^2 - 2P''P \cdot PG$. But $PG = \frac{CP^2}{PQ}$. Therefore $CP'^2 = P'P^2 + PC^2 + \frac{2P'P \cdot PC^2}{PQ}$. And

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* *Note.* The case where the point falls in the circumference of the circle, was considered in Proposition I., and therefore is here omitted.

$CP''^2 = P''P^2 + PC^2 - \frac{2P''P\cdot PC^2}{PQ}$. By reduction, $CP'^2 = \frac{P'P^2\cdot PQ + PC^2\cdot PQ + 2P'P\cdot PC^2}{PQ} = \frac{P'P^2\cdot 2PO + PC^2\cdot 2P'O}{2PO} = \frac{P'P^2\cdot PO + PC^2\cdot P'O.}{PO}$ And $CP''^2 = \frac{P''P^2\cdot PO + PC^2\cdot P''O.}{PO}$ But $P'P = P'O - PO$, and $P''P = PO - P''O$. Therefore, $CP'^2 = \frac{(P'O-PO)^2\cdot PO + PC^2\cdot P'O}{PO}$; & $CP''^2 = \frac{(PO-P''O)^2\cdot PO + PC^2\cdot P''O}{PO}$.

Wherefore CP'^4

$$= \frac{(P'O-PO)^4\cdot PO^2 + 2(P'O-PO)^2\cdot PO\cdot PC^2\cdot P'O + PC^4\cdot P'O^2}{PO^2};$$

and CP''^4

$$= \frac{(PO-P''O)^4\cdot PO^2 + 2(PO-P''O)^2\cdot PO\cdot PC^2\cdot P''O + PC^4\cdot P''O^2}{PO^2}.$$

By the same mode of reasoning, it may be shewn, that $BP'^4 = \frac{(P'O-PO)^4\cdot PO^2 + 2(P'O-PO)^2\cdot PO\cdot PB^2\cdot P'O + PB^4\cdot P'O^2}{PO^2}$;

and $BP''^4 = \frac{(PO-P''O)^4\cdot PO^2 + 2(PO-P''O)^2\cdot PO\cdot PB^2\cdot P''O + PB^4\cdot P''O^2}{PO^2}$:

and so of all the other lines drawn from the angular points to P' or P''.

Let n denote the number of the sides of the figure; and R, the radius, or PO. Then $CP'^4 + BP'^4 + \&c. = \frac{R^2\cdot\overline{(P'O-R)^4 + (P'O-R)^4 + \&c.} + 2(P'O-R)^2\cdot P'O\cdot R \times \overline{PC^2 + PB^2 + \&c.} + P'O^2\cdot\overline{PC^4 + PB^4 + \&c.}}{R^2}$ But, $(P'O-R)^4 + (P'O-R)^4 + \&c. = n(P'O-R)^4$. And (Lemma 4th.) $PC^2 + PB^2 + \&c. = 2nR^2$. And (Prop. I.) $PC^4 + PB^4 + \&c. = 6nR^4$. Hence, $CP'^4 + BP'^4 + \&c. =$

$$= \frac{nR^2(P'O-R)^4 + 4nR^2(P'O-R)^2\cdot P'O\cdot R + 6nR^4\cdot P'O^2}{R^2} =$$

$n\cdot\overline{(P'O-R)^4 + 4(P'O-R)^2\cdot P'O\cdot R + 6R^2\cdot P'O^2} = n\cdot\overline{P'O^4 - 4P'O^3\cdot R + 6P'O^2\cdot R^2 - 4P'O\cdot R^3 + R^4 + 4P'O^3\cdot R - 8P'O^2\cdot R^2 + 4P'O\cdot R^3 + 6P'O^2\cdot R^2} = n\cdot\overline{P'O^4 + 4P'O^2\cdot R^2 + R^4} = nR^4 + 4nR^2\cdot P'O^2 + n\cdot P'O^4.$

In like manner, $CP''^4 + BP''^4 + \&c. = nR^4 + 4nR^2 \cdot P''O^2 + n \cdot P''O^4$. Q. E. D.

Cor. Let m be any number less than n; the sum of the $2m$th powers of the lines will be $nR^{2m} + nx^2A^2R^{2m-2} + nx^4B^2R^{2m-4} + nx^6C^2R^{2m-6} + \&c.$ in which x denotes the line drawn from the assumed point to the centre of the circle, A the co-efficient of the second term of a binomial raised to the mth power, B of the third term, C of the fourth, &c.

Proposition III.

LET there be any regular figure, of a greater number of sides than three, circumscribed about a circle; and from any point in the circumference of the circle, let there be drawn perpendiculars to all the sides of the figure; twice the sum of the cubes of the perpendiculars, will be equal to five times the multiple of the cube of the radius of the circle, by the number of the sides of the figure.

Thus, if n denote the number of the sides of the figure; and R, the radius of the circle; twice the sum of the cubes of the perpendiculars, will be equal to $5nR^3$.

DEMONSTRATION.

Let O (Plate III. Fig. 7) be any circle, and A, B, C, D, &c. the points of contact of the sides of any regular figure, of more than three sides, circumscribed about it. Let P be any point in the circumference; and draw PM, PN, &c. perpendicular to SI, IK, &c. the sides of the figure. Draw the diameter PQ, and also PC, PB, &c. to all the points of contact. And from all the points of contact, draw CG, BH, &c. perpendicular to the diameter PQ.

It may be shewn, (as in Lemma 4th.) that $PM = PG$; and $PN = PH$; and so of all the other perpendiculars. But by the nature of the circle, $PM = PG = \frac{PC^2}{PQ} = \frac{PC^2}{2R}$. Hence $PM^3 = \frac{PC^6}{8R^3}$. In like manner, $PN^3 = \frac{PB^6}{8R^3}$. And so of all the other perpendiculars. Hence, by addition, $PM^3 + PN^3 + \&c. = \frac{PC^6 + PB^6 + \&c.}{8R^3}$ But (Cor. Prop. I.) $PC^6 + PB^6 + \&c. =$

$20nR^6$. Hence $PM^3+PN^3+\&c.=\frac{20nR^6}{8R^3}$. And $2\cdot\overline{PM^3+PN^3+\&c.}=\frac{40nR^6}{8R^3}=5nR^3$. Q. E. D.

Proposition IV.

LET there be any regular figure, of a greater number of sides than four, circumscribed about a circle; and from any point in the circumference of the circle, let there be drawn perpendiculars to the sides of the figure; eight times the sum of the fourth powers of the perpendiculars, will be equal to thirty-five times the multiple, by the number of the sides of the figure, of the fourth power of the radius of the circle.

Thus, if n denote the number of the sides of the figure; and R, the radius of the circle; eight times the sum of the fourth powers of the perpendiculars, will be equal to $35nR^4$.

DEMONSTRATION.

Let O (Plate III. Fig. 7) be any circle, and A, B, C, D, E, &c. the points of contact of the sides of any regular figure, of more than four sides, circumscribed about it; and let the same construction be made, as in Proposition III.

By a process of reasoning, similar to that in Prop. III., it may be shewn that $PM^4=\frac{PC^8}{16R^4}$, and $PN^4=\frac{PB^8}{16R^4}$. And so of all the other perpendiculars. Therefore, $PM^4+PN^4+\&c.=\frac{PC^8+PB^8+\&c.}{16R^4}$. But, (Cor. Prop. I.) $PC^8+PB^8+\&c.=70nR^8$. Therefore, $PM^4+PN^4+\&c.=\frac{70nR^8}{16R^4}$. Or, by multiplication, $8\cdot\overline{PM^4+PN^4+\&c.}=\frac{560nR^8}{16R^4}=35nR^4$. Q. E. D.

Cor. In general, let there be any regular figure circumscribed about a circle; let n denote the number of its sides; and let m be any number less than n: let R denote the radius of the circle; and from any point in the circumference, let there be drawn perpendiculars to the sides of the figure: the sum of the mth powers of the perpendiculars will be equal to

$n \times \frac{1\cdot3\cdot5\cdot7\cdots2m-1}{1\cdot2\cdot3\cdot4\cdots m} \times R^m$; where the numbers 1, 3, 5, 7, &c. are to be continued until the last be equal to $2m-1$; and the numbers 1, 2, 3, 4, &c., until the last equal m.

For, let the figure in the Proposition be supposed to have n sides. Then, reasoning as before, $PM^m + PN^m +$ &c. $= \frac{PC^{2m} + PB^{2m} + \&c.}{2^m R^m}$ But, (Cor. Prop. I.) $PC^{2m} + PB^{2m} +$ &c. $=$ $n \times \frac{1\cdot3\cdot5\cdot7\cdots2m-1}{1\cdot2\cdot3\cdot4\cdots m} \times 2^m R^{2m}$. Whence $PM^m + PN^m +$ &c. $=$ $n \times \frac{1\cdot3\cdot5\cdot7\cdots2m-1}{1\cdot2\cdot3\cdot4\cdots m} \times 2^m R^{2m} \div 2^m R^m = n \times \frac{1\cdot3\cdot5\cdot7\cdots2m-1}{1\cdot2\cdot3\cdot4\cdots m} \times R^m$.

Proposition V.

LET there be any regular figure circumscribed about a circle, of a greater number of sides than three; and from any point within the figure, let there be drawn perpendiculars to the sides of the figure; and likewise let there be drawn a right line to the centre of the circle: twice the sum of the cubes of the perpendiculars will be equal to twice the multiple of the cube of the radius of the circle, by the number of the sides of the figure; together with thrice the multiple, by the same number, of the solid, whose base is the square of the line drawn to the centre, and altitude, the radius of the circle.

Thus, if n denote the number of the sides of the figure; R, the radius of the circle; and d, the line drawn from within the figure, to the centre of the circle; twice the sum of the cubes of the perpendiculars will be equal to $2nR^3 + 3nd^2R$.

*DEMONSTRATION.**

Let O (Plate III. Fig. 8) be any circle, and F, A, B, C, &c. the points of contact of the sides of any regular figure, of more than three sides, circumscribed about it.

Case I. Let V be any point within the circle; and draw VH, VS, &c. perpendicular to KG, GM, &c., the sides of the

* *Note.* The case where the point falls in the circumference of the circle, was considered in Proposition III., and therefore is here omitted.

figure. Through V, draw the diameter PQ. With the centre O, and distance OV, describe a circle. Draw OA, OF, &c. to all the points of contact, from the centre. From V, draw Vh, Vs, &c. perpendicular to OA, OF, &c. respectively. From the points a, f, &c., where the lines OA, OF, &c. cut the circumference of the smaller circle, draw ap, fq, &c. perpendicular to the diameter PQ.

Since OA is perpendicular to KG, it is parallel to VH; and because Vh is perpendicular to OA, it is parallel to KG. Therefore, VHAh is a parallelogram; and VH$=$Ah. And because the perpendiculars Vh, and ap, are drawn from the opposite ends of the same arch Va, to the radii, OA and OP, passing through the extremities of the same arch; therefore Pp=Ah=VH. In like manner, Pq=VS; and so of all the other perpendiculars.

Now it is manifest, that the radii OA, OF, &c. divide the circumference of the smaller circle, at the points a, f, &c. into as many equal parts, as they do that of the greater; and moreover, that the lines Vp, Vq, &c. are respectively equal to perpendiculars drawn from V, to the sides of a regular figure circumscribed about the smaller circle, by drawing tangents to it at the points a, f, &c.; as was shewn in the demonstration of Lemma 4th.

Now $Pp=PV+Vp=PO-VO+Vp=R-d+Vp$. Hence, $Pp^3=(\overline{R-d}+Vp)^3=(R-d)^3+3(R-d)^2\cdot Vp+3(R-d)\cdot Vp^2+Vp^3$. In like manner, $Pq^3=(R-d)^3+3(R-d)^2\cdot Vq+3(R-d)\cdot Vq^2+Vq^3$: and so of all the rest.

Hence, $Pp^3+Pq^3+\&c.=(R-d)^3+(R-d)^3+\&c.+3(R-d)^2\cdot\overline{Vp+Vq+\&c.}+3(R-d)\cdot\overline{Vp^2+Vq^2+\&c.}+Vp^3+Vq^3+\&c.$

But $(R-d)^3+(R-d)^3+\&c.=n(R-d)^3$; and (Lemma 3d.) $Vp+Vq+\&c.=nd$, (where d denotes the radius of the smaller circle;) and (Cor. Prop. IV.) $Vp^2+Vq^2+\&c.=\frac{3}{2}nd^2$, ($m$, in the general expression, being in this case 2;) and (Prop. III.) $Vp^3+Vq^3+\&c.=\frac{5}{2}nd^3$.

Therefore, $Pp^3+Pq^3+\&c.=n(R-d)^3+3nd(R-d)^2+\frac{9}{2}nd^2(R-d)+\frac{5}{2}nd^3=n\cdot\overline{R^3-3R^2d+3Rd^2-d^3+3R^2d-6Rd^2+3d^3+\frac{9}{2}Rd^2-\frac{9}{2}d^3+\frac{5}{2}d^3}=n\cdot\overline{R^3+\frac{3}{2}d^2R}$.

Hence, $2\cdot\overline{Pp^3+Pq^3+\&c.}=2\cdot\overline{VH^3+VS^3+\&c.}=2nR^3+3nd^2R$.

CASE II. (Fig. 9.) Let the point V be taken without the circumference of the circle; and let the same construction be made as before.

It may be shewn, as in Case 1st., that $Pp = VH$; and $Pq = VS$; and so of all the other perpendiculars.

Now $Pp = Vp - VP = Vp - (VO - PO) = Vp - (d - R.)$ Hence $Pp^3 = (\overline{Vp - d - R})^3 = Vp^3 - 3Vp^2 \cdot (d-R) + 3Vp \cdot (d-R)^2 - (d-R)^3$. In like manner, $Pq_3 = Vq^3 - 3Vq^2 \cdot (d-R) + 3Vq \cdot (d-R)^2 - (d-R)^3$. And so of all the rest.

Hence, $Pp^3 + Pq^3 + \&c. = Vp^3 + Vq^3 + \&c. - 3(d-R) \cdot \overline{Vp^2 + Vq^2 + \&c.} + 3(d-R)^2 \cdot \overline{Vp + Vq + \&c.} - \overline{(d-R)^3 + (d-R)^3 + \&c.}$

But, (as in Case 1st.) $Vp^3 + Vq^3 + \&c. = \frac{5}{2} nd^3$; and $Vp^2 + Vq^2 + \&c. = \frac{3}{2} nd^2$; and $Vp + Vq + \&c. = nd$; and $(d-R)^3 + (d-R)^3 + \&c. = n(d-R)^3$.

Therefore, $Pp^3 + Pq^3 + \&c. = \frac{5}{2} nd^3 - \frac{9}{2} nd^2 (d-R) + 3nd (d-R)^2 - n(d-R)^3 = n \cdot \overline{\frac{5}{2} d^3 - \frac{9}{2} d^3 + \frac{9}{2} d^2 R + 3d^3 - 6d^2 R + 3dR^2 - d^3 + 3d_2 R - 3dR^2 + R^3} = n \cdot \overline{R^3 + \frac{3}{2} d^2 R}$.

Hence, $2 \cdot \overline{Pp^3 + Pq^3 + \&c.} = 2 \cdot \overline{VH^3 + VS^3 + \&c.} = 2nR^3 + 3nd^2 R$. Q. E. D.

Proposition VI.

LET there be any regular figure of a greater number of sides than four, circumscribed about a circle; and from *any point*, let there be drawn perpendiculars to the sides of the figure; and likewise a right line to the centre of the circle: eight times the sum of the fourth powers of the perpendiculars, will be equal to eight times the multiple by the number of the sides of the figure, of the fourth power of the radius of the circle; together with twenty-four times the multiple by the same number of the fourth power of the line whose square is equal to the rectangle contained by the radius and the line drawn to the centre; together with three times the multiple of the fourth power of the line drawn to the centre of the circle, by the number of the sides of the figure.

Thus, if n denote the number of the sides of the figure; d, the line drawn from the assumed point to the centre of the circle; and R, the radius of the circle; eight times the sum of the fourth powers of the perpendiculars, will be equal to $8nR^4+24nd^2R^2+3nd^4$.

*DEMONSTRATION.**

CASE I. (Fig. 10.) Let the point be taken any where, within the figure; and when without the circle, let it be denoted by V; and when within, by V′. Let the same construction be made, as in Proposition V. (excepting that the figure shall have more than four sides;) and let the intersections of the lines drawn perpendicular to PQ, from all the points f, a, b, c, d, &c., when the point is taken within the circle, be denoted by q', p', &c.

It may be shewn, (as in Case 1st. of Proposition V.) that $V'H = Pp' = R-d+V'p'$; and $V'S=Pq'=R-d+V'q'$. And, (as in Case 2d. of the same Proposition,) that $VH=Pp=Vp-(d-R)$; and $VS=Pq=Vq-(d-R)$; and so of all the rest in either case.

Hence, $Pp'^4=(V'p'+\overline{R-d})^4=V'p'^4+4V'p'^3\cdot(R-d)+6V'p'^2\cdot(R-d)^4+4V'p'\cdot(R-d)^3+(R-d)^4$; and $Pq'^4=V'q'^4+4V'q'^3\cdot(R-d)+6V'q'^2\cdot(R-d)^2+4V'q'\cdot(R-d)^3+(R-d)^4$; and so of the rest.

In like manner, $Pp^4=(Vp-\overline{d-R})^4=Vp^4-4Vp^3\cdot(d-R)+6Vp^2\cdot(d-R)^2-4Vp\cdot(d-R)^3+(d-R)^4$; and $Pq^4=Vq^4-4Vq^3\cdot(d-R)+6Vq^2\cdot(d-R)^2-4Vq\cdot(d-R)^3+(d-R)^4$; and so of the rest.

Hence, $Pp'^4+Pq'^4+\&c. = V'p'^4+V'q'^4+\&c.+4(R-d)\cdot\overline{V'p'^3+V'q'^3+\&c.}+6(R-d)^2\cdot\overline{V'p'^2+V'q'^2+\&c.}+4(R-d)^3\cdot\overline{V'p'+V'q'+\&c.}+(R-d)^4+(R-d)^4+\&c.$

And $Pp^4+Pq^4+\&c. = Vp^4+Vq^4+\&c.-4(d-R)\cdot\overline{Vp^3+Vq^3+\&c.}+6(d-R)^2\cdot\overline{Vp^2+Vq^2+\&c.}-4(d-R)^3\cdot\overline{Vp+Vq+\&c.}+(d-R)^4+(d-R)^4+\&c.$

Now, for the reasons assigned in Case 1st. of Proposition V., (by Prop. IV.) $V'p'^4+V'q'^4+\&c.=\frac{35}{8}nd^4$; and (Prop. III.) $V'p'^3+V'q'^3+\&c.=\frac{5}{2}nd^3$; and (Coroll. Prop. IV.) $V'p'^2+V'q'^2+\&c.=\frac{3}{2}nd^2$; and, (Lemma 3d.) $V'p'+V'q'+\&c.=nd$; and $(R-d)^4+(R-d)^4+\&c.=n(R-d)^4$.

* *Note.* The case where the point falls in the circumference of the circle, was considered in Proposition IV.; and therefore is here omitted.

Therefore, $Pp'^4+Pq'^4+\&c.=\frac{35}{8}nd^4+10nd^3(R-d)+9nd^2(R-d)^2+4nd(R-d)^3+n(R-d)^4$.

In like manner, $Pp^4+Pq^4+\&c.=\frac{35}{8}nd^4-10nd^3(d-R)+9nd^2(d-R)^2-4nd(d-R)^3+n(d-R)^4$. Or, $Pp'^4+Pq'^4+\&c.$ $=n\cdot\overline{\frac{35}{8}d^4+10d^3R-10d^4+9d^2R^2-18d^3R+9d^4+4dR^3-12d^2R^2+12d^3R-4d^4+R^4-4dR^3+6d^2R^2-4d^3R+d^4}=n\cdot\overline{R^4+3d^2R^2+\frac{3}{8}d^4}$.

And $Pp^4+Pq^4+\&c.=n\cdot\overline{\frac{35}{8}d^4-10d^4+10d^3R+9d^4-18d^3R+9d^2R^2-4d^4+12d^3R-12d_2R_2+4dR^3+d^4-4d^3R+6d^2R^2-4dR^3+R^4}$ $=n\cdot\overline{R^4+3d^2R^2+\frac{3}{8}d^4}$.

Hence, $8\cdot\overline{Pp'^4+Pq'+\&c.}=8\cdot\overline{V'H^4+V'S^4+\&c.}=8nR^4+24nd^2R^2+3nd^4$.

And $8\cdot\overline{Pp^4+Pq^4+\&c.}=8\cdot\overline{VH^4+VS^4+\&c.}=8nR^4+24nd^2R^2+3nd^4$.

Case II. (Fig. 11.) Let the point V be taken without the figure; and the same construction be made as before.

It may be shewn as before, that $VH=Pp$, and $VS=Pq$, and so of all the rest.

It is manifest also, that when the sides of the figure produced, fall between the assumed point and the figure, the lines Pp, Pq, &c. will fall between P and V; but, that otherwise, they will fall on the other side of P.

Hence, $VH=Pp=VP\backsim Vp=Vp\backsim(d-R)$; and $VS=Pq=VP\backsim Vq=Vq\backsim(d-R)$; and so of all the other perpendiculars.

Then, $Pp^4=(Vp\backsim\overline{d-R})^4=Vp^4-4Vp^3\cdot(d-R)+6Vp^2\cdot(d-R)^2-4Vp\cdot(d-R)^3+(d-R)^4$; and $Pq^4=Vq^4-4Vq^3\cdot(d-R)+6Vq^2\cdot(d-R)^2-4Vq\cdot(d-R)^3+(d-R)^4$; and so of all the rest.

Hence, $Pp^4+Pq^4+\&c.=Vp^4+Vq^4+\&c.-4(d-R)\cdot\overline{Vp^3+Vq^3+\&c.}+6(d-R)_2\cdot\overline{Vp^2+Vq^2+\&c.}-4(d-R)^3\cdot\overline{Vp+Vq+\&c.}+(d-R)^4+(d-R)_4+\&c.$

But, as in the first case, Vp^4+Vq^4+ &c. $\frac{35}{8}nd^4$ (by Prop. IV.) and (Prop. III.) $Vp^3+Vq^3+=\frac{5}{2}nd^3$; and, (Cor. Prop. IV.) Vp^2+Vq^2+ &c. $=\frac{3}{2}nd^2$; and, (Lemma 3d.) $Vp+Vq+$ &c. $=nd$; and, $(d-R^4)+(d-R)^4+$ &c. $=n\,(d-R)^4$.

Therefore, Pp^4+Pq^4+ &c. $=\frac{35}{8}nd^4-10nd^3\,(d-R)+9nd^2$
$(d-R)^2-4nd\,(d-R)^3+n\,(d-R)^4=n\cdot\overline{\frac{35}{8}d^4-10d^4+10d^3R+}$
$\overline{9d^4-18d^3R+9d^2R^2-4d^4+12d^3R-12d^2R^2+4dR^3+d^4-4d^3R+}$
$\overline{6d^2R^2-4dR^3+R^4}=n.\,\overline{R^4+3d^2R^2+\frac{3}{8}d^4}.$

Hence, $6\cdot\overline{Pp^4+Pq^4+\text{\&c.}}=8\cdot\overline{VH^4+VS^4+\text{\&c.}}=8nR^4+24nd^2R^2+3nd^4$. Q. E. D.

Cor. In general, let there be any regular figure circumscribed about a circle; and let n denote the number of its sides: let m be any number less than n; and R the radius of the circle; and from any point, (within the figure, if m be an odd number; but if even, from *any* point, either within or without,) let there be drawn perpendiculars, to the sides of the figure; and likewise a right line to the centre of the circle; and let v denote the line drawn to the centre; and let a be the co-efficient of the third term of a binomial, raised to the mth power; b, the co-efficient of the fifth term; c, the co-efficient of the seventh term, and so on: the sum of the mth powers of the perpendiculars will be equal to $nR^m+nAv^2R^{m-2}+nBv^4R^{m-4}+nCv^6R^{m-6}+$ &c.; substituting A for $a\times\frac{1}{2}$; B, for $b\times\frac{1\cdot3}{2\cdot4}$; C, for $c\frac{1\cdot3\cdot5}{2\cdot4\cdot6}$, and so on. Which expression may be shewn to be true, by reasoning for the 5th, 6th, &c. powers of the perpendiculars, in the same manner as in the two preceding propositions.

Note. The odd powers of the perpendiculars are confined to the figure, because, otherwise, in summing up, (as in Case 2d.) of this Prop.) part of the odd powers of the lines Vp, Vq, &c. will be affirmative, and part negative; that is, part to be added, and part subtracted; and their sum cannot be found.

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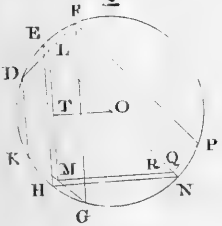

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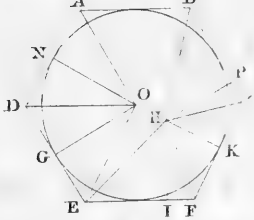

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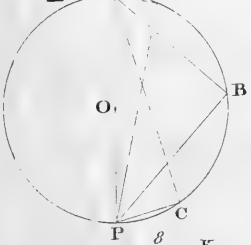

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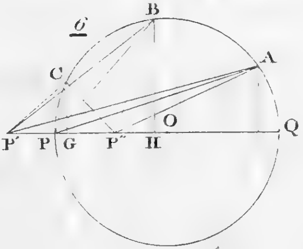

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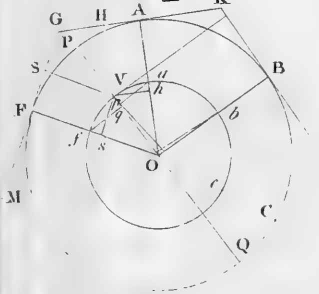

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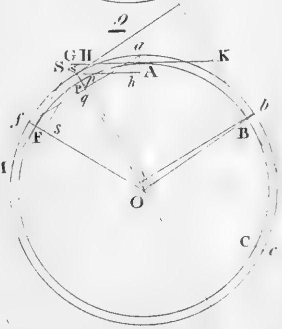

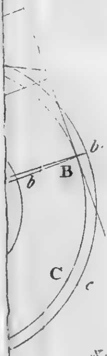

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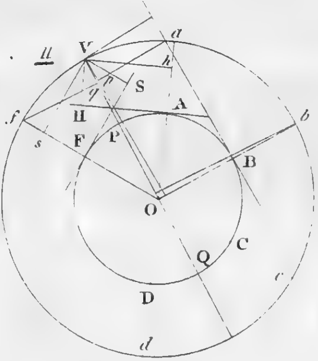

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Pl. III.