Samuel Ewell

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DISCOURSES

ECONOMICAL & PHILOSOPHICAL,

DETAILING

THE PROPERTIES OF MATTER.

John Sparrow

Nov. 24. 1807

PLAIN DISCOURSES

ON THE

LAWS OR PROPERTIES OF MATTER:

CONTAINING

THE ELEMENTS OR PRINCIPLES

OF

MODERN CHEMISTRY;

WITH

MORE PARTICULAR DETAILS OF THOSE PRACTICAL PARTS

OF THE

SCIENCE

MOST INTERESTING TO MANKIND,

AND

CONNECTED WITH DOMESTIC AFFAIRS.

Addressed to all American promoters of useful knowledge.

By THOMAS EWELL, M. D. of Virginia.

ONE OF THE SURGEONS OF THE UNITED STATES NAVY.

" Humanity sitting at the portal of misery, through the medium of Science implores relief, while a tear is dropt for the unfortunate children of men."

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1806.

TO

THOMAS JEFFERSON, *Esq.*

OF VIRGINIA,

THE PRESIDENT OF THE UNITED STATES OF AMERICA.

SIR,

TO inscribe this work to you, I was incited by an impulse given from a view of your station, as well as a sense of favors received. Raised by your own qualities, and the will of a free people, to the first place among them, the legitimacy of your title will be questioned by none.

IN preparing the following plain discourses, I was stimulated by a desire to imitate you in doing good. I was anxious to revolutionize the habits of many of our countrymen; to lessen their difficulties, by acquainting them with important improvements, and to diffuse more widely that genuine happiness derived from the interesting study of the ways of nature.

YOU, sir, have long since enjoyed the luxury of serving your countrymen.

WITHOUT expressing sentiments concerning your services as a statesman, in affairs better suited to my opportunities of observing, *I perceive that you have been useful to your country. With a benevolence without bounds, the scenes of elevation and pleasure could not prevent your sympathizing with the sorrows of those groaning in the retired walks of life. You have been foremost in setting the example of introducing in society improvements in various arts. Such as have engaged in useful innovation under your notice, feelingly tell of the generosity of your patronage. Many of the rising generation owe their prosperity to that liberality of sentiment so seldom met with, but which has so often led you to favor the young. To a virtuous mind it must be pleasing to reflect, that the thankful will long bear in remembrance your parental goodness. In future days they will emulate each other, in the celebration of your worth, while you are associated among the benefactors of mankind.*

THAT your happiness may be equal to your services, and that your successors may imitate the mildness and wisdom displayed during your career, are among the sincere wishes of

Your Respectful and

Obliged Servant,

THOMAS EWELL.

PREFACE.

THE following plain work I prepared with a view to lessen the difficulties, and to increase the conveniences of the citizens of the United States, by introducing them to a more intimate acquaintance with chemistry, or the qualities of the substances around them. The immense advantages which will result from the general diffusion of such knowledge, are glanced at in the introductory discourse. These advantages, I have indulged in the hope, will lead the respectable farmers and artists, the benevolent editors of publications, particularly the teachers of seminaries, my brethren of the medical faculty, and the intelligent of every denomination, to favor and promote the undertaking. As expressed in the title page, the work will contain a general account of the laws or properties of matter, with more particular details of the most useful and interesting parts of the science, in a language adapted to the comprehension of common understandings. I designed to lessen the number of technical terms in this elementary work, by excluding all such as are of no importance, and such as relate to the less valuable refinements of chemistry, which could only be gratifying to professional and very learned characters. The terms which are introduced, I have endeavored to render as intelligible as possible. It was expected that this would so lessen the difficulty of learning the most important branches of chemistry, as no longer to prevent the majority of the people from engaging in the pursuit. To persons of sound sense, it must at once appear, that the best method of inducing others to study a science, is to render it as simple as it can be. Hence it must appear highly improper, that so many elementary books are crowded with a parade of words. The following extracts of letters with which I was favored from the President, and from the honorable Bushrod Washington, may not be improperly introduced in this place.

"MONTICELLO, AUGUST 1805.

"OF the importance of turning a knowledge of chemistry to household purposes, I have been long satisfied. The common herd of philosophers seem to write only for one another. The chemists have filled volumes on the composition of a thousand substances of no sort of importance to the purposes of life; while the arts of making bread, butter, cheese, vinegar, soap, beer, cider, &c. remain unexplained. Chaptal has lately given the chemistry of wine making; the late Dr. Pennington did the same as to bread, and promised to pursue the line of rendering his knowledge useful to common life; but death deprived us of his labors. Good treatises on these subjects should receive general approbation.

"TH: JEFFERSON."

"MOUNT-VERNON, 13th SEPT. 1805.

"I have long thought that a work upon the plan you suggest, was much wanted by those who form the great bulk of readers on chemical subjects. I have not met with a single treatise which has not appeared unnecessarily obscured by technical terms, which only scholars can understand. They have been more generally addressed to the comprehension of professional and learned men, than to those of the humble walks of life; for whose use this science might be made most essentially to contribute, by adapting it to their capacities, and by pointing out the way by which its principles may be applied to the more common arts, in which they are daily employed. You will I think do great good to society and much honor to yourself, by executing such a work as you propose. My best wishes will accompany you in your labors, and I shall be happy to aid them as far as I can.

"BUSH. WASHINGTON."

CHEMISTRY must be considered as an art and as a science. As an art, it was coeval with the earliest labors of man; but, as a science, it was unknown to our ancestors. Indeed, on taking a view of the researches of chemists in former times, we find considerable cause for complaint. The interests of mankind suffered shamefully by their neglecting chemistry as a science for so many ages. Moreover they acted so extravagantly as to disgust those with the pursuit from whom improvements might have been expected. For ages they professed to be acquainted with many of the operations of nature, and pretended to communicate their knowledge by certain signs, or hieroglyphics, which only a few could comprehend. They afterwards lost much time in ridiculous efforts to discover the art of transmuting metals, or converting the common ones into gold. These alchymists (for so they were called) long labored to discover medicines to cure all disorders, and secure immortality on earth. Some of them had the effrontery to announce, that in consequence of holding a converse with God, who imparted such secrets to his favorites, they could readily succeed in such wonderful acts. The brilliancy of some of their processes, striking the more forcibly from their fanciful manœuvres, was such as to excite as great curiosity as the amazing exploits reported in the days of chivalry. Dazzled and deluded by them, the credulous spectators admitted the assertions of these impostors, confided in their statements, looked on them with awe, and successively became dupes to their designs. Many, even in the middle of the 16th century, credited these alchymists, till a fatal blow was given to such impositions by the timely death of their enthusiastic Paracelsus, who declared, that by virtue of his medicines he would live for ever. The death of this deluded wretch, was followed by the complete downfal of the chemists over all Europe; and for a long time so contemptible was their character, that it was deemed disgraceful to be called a chemist.

IN a state of darkness and contempt, chemistry continued to be held, until men embraced the science whose expectations were reasonable. Towards the last of the 16th and commencement of the 17th centuries, respectable gentlemen engaged in the study, made interesting discoveries, and partly restored the science to its proper rank. But they did not quite succeed; for instead of noticing facts and making inferences from these, they indulged in conjecture. The doctrine of the formation of all bodies from air, fire, and three or four other supposed elementary bodies, was then delivered, in all the fulness of philosophic confidence, with many other notions alike not founded on fact. For this, however, a remedy has lately appeared. A few years since men of the first talents advanced and created a revolution in the literary world. Animated by a love of truth, they embraced the science of chemistry, and in the embrace gave it new importance. Their discoveries have confounded the conjectures of predecessors; they have taught mankind the folly of their prejudices against chemistry, and they have revealed the proper objects of the science. Some of our infant country have aided in the glorious reformation and establishment. The celebrated chemist, Dr. Mitchill of the United States senate, has made some ingenious suggestions in the Medical Repository of New-York; a work conducted by himself, and the not less learned and accomplished Dr. Miller. The accurate experimenter, Professor Woodhouse of Philadelphia, and the learned Dr. Mac Lean of Princeton College are among the foremost on the list of chemists in this country. It is from the interesting lectures of these respectable characters, that many of the rising generation have received a love for chemistry.

ALTHOUGH it be true that modern chemists have been of great service, yet it is equally so, that the value of some of their labors, has been lessened by a too active spirit of innovation. This has led them to introduce, unnecessarily, terms from the dead languages; and to make too many divisions and subdivisions in their works, which are directly at war with the uniform simplicity of nature. While writing these discourses, if I studied at all, I studied to avoid such extremes. However, as should be expected, I availed myself of the writings of the best chemists. When conscious of an inability to improve, I imitated their manner of stating facts. To the systems of chemistry by Thompson, Chaptal, Murray, and particularly that by Mr. Accum, I am indebted. The copious extracts from this last author will much increase the value of this work. But I have not been a very servile imitator. It will be found that I have advanced something new on the subjects of heat, light, electricity, vegetation, manures, and also on several other branches of chemistry. Such original observations are introduced from the belief that they were correct. They served to impress me more forcibly with a great man's remark, that "Truth is not hidden, it lies on the surface." Even if I have missed it on the surface, allowances will be made, when it is considered, *that the chief part of my time has been devoted to my favorite pursuit after a knowledge of the practice of physic;* and that with a view to turn the attention of others to chemistry, I prepared this work in those leisure hours which young physicians have, in consequence of the too common belief, that the success of the healing art depends not so much on the application of principles to practice, as on experience, or something like sleight of hand. It will be found that the most material doctrines I have proposed are extensions of the principles relating to operations in animal bodies, which were advanced in my Inaugural Essay, published during my attendance on the hospital in Philadelphia, 1804, and which were supported by the approbation of Dr. Rush and other gentlemen of the faculty. This served to increase the confidence with which I ventured to introduce them in this book. The attention I have paid to each subject was regulated by its known importance; and I have studied brevity to avoid fatiguing the reader.

IT was deemed unnecessary to give the biography of the celebrated chemists, although it be common for systematic authors to do it. The pleasure of making a discovery was a sufficient reward for innovators, who, if properly philanthropic, wished posterity to learn their improvements, before they read accounts of their lives. Nor have I thought proper to crowd the pages with the names of authors while mentioning their discoveries, or to notice the many erroneous theories and conjectures which have been obtruded on the world; occasionally, however, I have been obliged to hint at some of them.

THE table of contents will serve as an index to the work. Definitions of such words, as were unavoidably introduced, are given at the end of the discourses, in order that if their meaning be forgotten, or if there be some who wish not to be at the trouble of reading more than one or two parts, they may understand them with least difficulty.

IT would not be proper for me to omit acknowledging my obligations to the accomplished scholar and Secretary of the Navy, the Hon. Robert Smith, and also to Judge Washington, the benevolent Mecænas of Mount Vernon. They gave me that patronage which enabled me the better to progress in this undertaking. It is pleasing to reflect, that such characters have always a reward for their friendly exertions, in the delight they take in so acting.

INTRODUCTORY ADDRESS.

INTRODUCTORY ADDRESS.

ARTISTS, FARMERS, & FELLOW-CITIZENS,

I HERE offer you a work, prepared to render you better acquainted with chemistry, or the properties of that matter amidst which you are placed. By the important promotion of your own interests, by the high delight I shall derive from being instrumental in serving you, I pray you to read, to think, to dwell on the researches of chemical philosophers. In the view of these researches, which I am about to give, defects may be noticed. To screen me from the condemnation of the censorious, I have to entreat you to consider my intention as a cover to what will be communicated, and to allow the performance to rest on that good, which must result from a general attention to the facts and principles it will contain.

MUCH indeed is it to be lamented, that so considerable a part of the community seldom think for themselves, or are in the least aided by the labors of their forefathers. Notwithstanding the truth proclaimed in all ages, that the pleasures are derived from the actions of life, yet we frequently find persons who persist in idleness; who will not endeavor to be benefited by the experience of those who lived before them. It is in consequence of not taking due advantage of the improvements of philosophers, that the greater part of the people are in situations loudly calling for amendment. From this, it is now particularly incumbent, on such as are intelligent, to be active in disseminating useful knowledge. Every citizen, regarding the welfare of his species, should strive to increase the dispositions to think, and to combine researches for knowledge, with labors for maintenance. By this, many would become qualified for acting more usefully, and much time would be spent agreeably, which is otherwise lost in sloth, or in devising schemes for low amusements.

OF the sciences which should be universally learnt, chemistry ranks among the first. Since its object is to instruct us in the qualities of those bodies surrounding us, where can limits be set to its value ? How interesting should it be to every individual ! Surely the friends of humanity should be industrious in imparting, to all classes of people, the blessings which may be derived from such an inexhaustible source.

THAT man, ignorant of the laws regulating the substances around him, or if he only acquire the inconsiderable knowledge afforded by his own experience and observation, is very far from a desirable state. He resembles a traveller in a strange country, who, if possessed of feeling, painfully progresses in consequence of fears concerning the propriety of his advances. His mind is so disturbed by difficulties, that he is entirely prevented from enjoying the fair prospects presented on the road. The cautious passenger through this world, to avoid such wretched states of uncertainty and hesitation, should early learn the properties of those bodies, with which he will have so much to deal.

In the time in which he is learning a few of their properties, which he often does without knowing that he is learning chemistry, he could treasure up far more information by studying the science systematically. What is of more importance, this knowledge would increase his independence, and might enable him to perfect, at least highly improve the improvements of his predecessors. No one will doubt this, when it is considered that although the science of chemistry has been studied properly only for a few years; and although but a small part of mankind have attended to it, yet a progress has been made, which astonished the world! Who could have believed an age ago, that chemists would thus early have been able to decompose the air we breathe, or the water we drink, and form them again! that they would have proved diamonds to be simply consolidated charcoal; that they could have converted flesh into spermaceti and saltpetre; or that they could have made many other discoveries which have amazed and delighted the greatest men within a few years? In order to form a correct idea of the importance of chemical knowledge, it will be necessary to glance at some remarkable facts; and at the connexions of the sciences with those arts on which our lives, comforts and luxuries materially depend.

THAT minds are much under the influence of art, that it is from education they receive their habits of action, will be admitted by all. On the truth of this, is grounded the practice of accustoming youths to that kind of thought most useful to society. Amongst the various kinds of mental action, there are none of more consequence, than the exercise of the judging and reasoning faculties. Now the principles of chemistry are inductions from facts, obvious to the lowest comprehension. In acquiring a knowledge of them, the facts are presented to us, and the inductions are determined on by the judgment. The reasoning faculty is exercised in comparing and arranging the facts and inferences or inductions. By this the judgment and reason become improved; the habit of intellectual action is extended, and it aids in the investigation of truth on many subjects. With propriety we may therefore conclude, that, if the science of chemistry were more generally studied, there would be less foundation for the remark of Swift, "that man was a rational though not a reasonable animal."

THE pleasures directly derived from chemistry, are inferior to none in degree or duration. Its sources yielding delight to the inquiring mind, are great and inexhaustible. The man acquainted with this science, has wide fields for enjoyment where least expected by the vulgar. To his eyes no bodies appear disorganized, deficient in action, or devoid of interesting qualities; even in the most inconsiderable objects he discovers beauties. The eruptions of volcanoes, earthquakes, meteors, and all the grand operations of nature, cease to excite in him that horror and dismay, disturbing the quiet of less thoughtful persons. In such processes, he perceives simply the exercise of the immutable laws of matter, which, while they announce the wisdom of the Creator, produce in him the purest philosophic devotion. Through the medium of matter, he learns the will of his Deity, and by this he is enabled, as Mr. Chaptal observes, to imitate the Creator in forming and decomposing bodies, and in predicting results with absolute certainty. And say, ye experienced chemists! what sensations ever seized your souls, so rapturous as those, felt on finding yourselves able to revolutionize the state of airs and solids! to regulate at pleasure powerful elements, the former sources of destruction and terror! You will also testify, that it is gratifying to learn the composition of bodies yielding a support and their connexion with each other, as well as the causes of the various changes, which take place in nature. After once feasting on the pleasures resulting from such researches, but few would relinquish them, for the fruitless pursuits of most of the people.

PERHAPS, too, at the closing scene of life, the philosophic chemist may be rewarded by pleasurable thoughts. Unlike the many souls which seem shattered at the prospect of having their bodies changed into putrid masses, and mingled with the earth, he may reflect on the new process with calmness and delight. Instead of trembling on finding his extremities losing their genial warmth, and growing dark with livid fluids; instead of giving way to shrieks and lamentations, while his perception is failing, his mind may be amused in contemplating the exercise of the laws of his visible body, until it takes a final departure for enjoyment in other scenes.

SUCH considerations, however, are inferior to those arising from an adversion to the immediate good, which chemical information will be of to important arts. It will enable most artists to extend the scale of their usefulness in a great degree. To form correct conceptions of this, we will here glance at those arts with which chemistry is closely connected ; and first of the most noble pursuit of man, the cultivation of the earth.

AGRICULTURE is most intimately connected with chemistry. The power of seed to attract and unite to parts of the soil, so as to vegetate or increase in bulk, is purely chemical. Chemical knowledge will teach the gardener and farmer, what particular soil is best adapted for particular seed; it will teach the way of forming soils for foreign plants; of making manures to the greatest advantage; of preserving grain, roots, &c. of destroying the insects, and of correcting the disorders injuring the valuable shrubs. In consequence of the ignorance of most farmers on this subject, they frequently blunder in a manner highly prejudicial to their interests. Sometimes they not only spread a particular manure, where it can be of little service, but they will use it in a state in which it is least valuable. The truth of this assertion is shown by the fact, that most animal substances may easily be changed into saltpetre; which is an article universally known to be an important manure; yet this is seldom or never done in this country. The wealth and independence of farmers, might also be increased by using many articles commonly thrown away. The ashes of the corn stalk, yielding potash for soap, and those of tobacco, yielding saltpetre, confirm this remark.

BUT such immediate advantages do not seem the limits of what the agricultural chemist should expect. The days I hope are approaching, when industrious man, happy in the exertion, and happy in the prospect---governed by the principles of chemistry, and penetrating by the principles of mechanics, will descend into the bosom of nature, will ransack all the bowels of the globe, will discover new fertilizing bodies, enabling him to give one common surface to the earth, thereby securing an uniformly rapid vegetation, at once displaying the smiles of a benevolent God, and the glories of the animal kingdom.

TO the art of farming, that of cooking is very nearly allied. The object of this art is to prepare food, and to render it most nourishing and palatable; which should entitle the cook to a respectable rank among the artists. The salting of meat, pickling and preserving vegetables, baking bread, &c. &c. depend on chemical principles. And on the same is founded the skill of the dairy maid in keeping milk sweet and fresh, in making butter and cheese, and preserving them pure. Improvements have not long since been made, by which the rancidity of butter, and tainted meats, can be corrected; and food can be so prepared, that one third the quantity commonly consumed, will support an individual. Perhaps more important discoveries may be made in this branch of chemistry, when prosecuted by persons of strong minds.

SUCH advantages are greatly exceeded by others, derived from a knowledge of heat. By a tolerable acquaintance with the laws of this substance, the citizens can, without a deprivation of comfort, so manage chimneys, ovens, furnaces, brick-kilns, distilleries, and all other receptacles of fire, as to consume not half the fuel generally used. The labor and money which this would be instrumental in saving to mankind, if properly attended to, would be immense. The propriety of the families, in the Atlantic states, immediately attending to this, is shown by the scarcity and difficulty of procuring wood; which in some parts is really distressing. The same intelligence will also lead to other improvements in common practices. It will enable men, not only to make excellent substitutes for ice, where it cannot be procured, but it will teach them of what materials to construct all vessels for containing ice, so that a quantity of it will last longer than double that quantity under common circumstances. By this the advantages and luxuries arising from ice, in hot countries, will be much more general; as the expences of preserving it will be greatly reduced. Moreover, this knowledge of heat, might lead to a most material diminution of the cost of clothes: thereby facilitating the arrival of those happy times, when the difficulties of living will be so lessened, that all may live alike; when an uniformity of habits will be established among men, the absence of which, now so frequently renders common life, and common "liberties but dreary gifts."

ALL the processes connected with the metals, such as separating them from their ores, purifying, forging, and casting them; forming particular combinations of them; as, brass, pewter, and printer's types; converting iron into steel, detecting the presence of such as are poisonous; as, arsenic, copper and lead; soldering them, &c. depend on chemistry. The composition of stones, and earth, form also a branch of this science. Had these subjects been earlier understood, much wealth would have been acquired, by the earlier discovery of mines and precious stones, which escaped common observers. And by the detection of the destructive metals, put in adulterated wines, and other drinks, many persons might have been longer preserved, who have fallen victims to such impositions.

CHEMISTRY, not only instructs us in the means of ascertaining the constituents of medicinal springs, but also in the art of forming waters similar to each. It teaches the method of making saltpetre and gunpowder; which, during all wars, is of such primary importance. This, with the arts of preparing the various kinds of salts, acids, and all the chemical medicines in the shops, which come under the head of pharmacy, might occasionally prove serviceable to most individuals; at least, it would be well to learn the principles on which they are compounded.

ANOTHER of the most important objects of chemistry is, to correct the impurity of those foul and infectious airs, which destroy animals. Many can readily recal to their minds the scenes of distress they have witnessed, or heard of, in consequence of the impurity of airs. But few have not read of the deaths occuring from this source, from the remotest to the present times. Accounts of the black hole of Calcutta, where so many Englishmen suddenly expired, are fresh in the memory of many; and no tales are more common than those concerning the deaths of persons entering mines, and rooms, and caves, in various parts of the country. This branch of the science, will not only be instrumental in saving lives, but, by holding out the means of correcting infected airs, will lead to the abolishment of those vexatious quarantine laws, which serve, in reality, only to injure merchants in a shameful degree, without benefiting any part of society.

THE arts of distilling, of ascertaining the strength and purity of spirits; and of preparing the various fermented fluids, such as vinegar, wine, porter, perry, cider, and yest, depend solely on chemical principles. Some of them have been highly improved in other countries. Since the pernicious practice of using large quantities of such drinks has become almost universal, it is of consequence that the knowledge of these improvements be general in this country. When this is the case, the considerable sums of money annually expended by individuals for spiritous liquors, may be in part saved for the education of their descendants, as such articles will be prepared at home, for much less money. Already, in some parts, the citizens have prepared from the fruit of the persimmon tree a brandy equal to the French; and from pears, a drink equal to wine, as I am credibly informed.

THE next branch of this science I shall mention is the purification of filthy waters. The importance of this will be best stated by the numerous mariners and persons who have suffered from the use of putrid waters. From late improvements, it is now completely in the power of every one, to avoid the difficulties arising from this old source of pain, disease, and death.

CHEMISTRY, also, teaches the arts of preparing and refining all the sugars and oils. This will prove a source of considerable emolument, if attended to by large families, as they will be enabled in many instances to prepare their sugars, and also various oils, from common plants.

THE art of tanning leather, which has lately been so much improved, the methods of making soap, glue, starch, paints, the varieties of inks and dyes; of bleaching, glazing, and enamelling; of making glass, porcelain, bricks, &c. depend on chemical principles; and by them alone can be explained and rationally improved.

THE traveller, distressed by the darkness of nights, and by the piercing extremes of cold, will derive relief from a knowledge of chemistry. It will direct him how to revolutionize the scenes around him, to give a new light and a new heat with astonishing facility.

IT is unquestionably true, that arts have been practised and some of them improved, by persons entirely ignorant of the principles on which they depended. For example, leather has been well tanned, colors beautifully dyed, and meats properly preserved, by the most uninformed persons. Sometimes very important improvements have been made by artists of this description. Their discoveries however were accidental, and for stumbling on them they deserved no reward. Moreover, when they possess a proper degree of feeling and foresight, their operations are slow and painful, because they are conscious that the termination is doubtful. Of the uncertainty of their processes, of their inability to calculate on results with confidence, the most experienced of them will speak. Now this state of doubts will be completely corrected, if the principles of the art, if chemistry, be learnt. Such knowledge would be to the artists, what money is to the commercial world. It would give them strength, confidence, and a firm support. Like money too, it would enable the possessor, to extend considerably the sphere of his usefulness. It might qualify each individual to make improvements in his art, which would endear him to mankind till the latest day. That we have good reason for indulging in such expectations, appears from the services already rendered the arts by a few chemists, who could do but little more than theorize. Surely, those daily in pursuit of a particular branch of the science, who sensibly experience the imperfections of its state, are better fitted for improving that branch, than the professed chemist, whose attention is alike claimed by all the branches. Independently of this, by studying the art systematically, or as a science, although it might not qualify them immediately for expertly practising them, yet it would enable them to learn their trade in one third the time commonly devoted to it. Another advantage resulting from the general study of chemistry, among the artists, would be the increase of liberality, which would follow the increase of their judging and reasoning powers. That most of them stand much in need of an increase of liberality, appears from the great opposition they constantly make to the suggestions and improvements of scientific characters, without fairly trying their value. We find, frequently, instances of such strong prejudices continuing for years. They seem so well satisfied with the state of their arts, that they ridicule and condemn every effort to improve, as extravagantly erroneous. Hence we find, that tanners refuse to tan leather in the same number of days that formerly required weeks: that in the construction of houses, no attention is paid to the laws of heat; and that farmers, in thousands of instances, will not do as their interests direct. The time it is hoped will soon come, when the benevolent philosophers, will not have so frequently to feel for their errors; when condemnation and contempt will no more be withheld from them, for the reason, that "they know not what they are doing."

OF late years chemistry has been taught publicly in the schools of Europe. In France great encouragement is given to the cultivators of this science. Its professors are supported, and in some instances have been generously rewarded by government. Under such circumstances, thousands annually learn the science without incurring expences. Since this has been the case, the most remarkable revolutions have been wrought in their manufactures; abuses have been corrected, processes simplified, and improvements made, which the most sanguine supposed scarcely possible. In addition to this, new manufactories have been erected, and important uses made of articles, which predecessors had long neglected. Worn out soils have been turned into sources yielding wealth and reputation to the industrious citizens! Nor did the chemists stop with this success. They advanced much farther; they entered the recesses of nature; they have hailed with pleasure the contents of the tomb, converting the putrid carcases into masses highly useful to living animals!

THE love of chemical pursuits has not been confined to men. That sex whose virtues reflect so much honor on the human race, caught the taste for this interesting study, particularly in France, the ladies enthusiastically espoused the cause of chemistry. The fate of the beloved lady Chevraud, who fell a victim to an experiment she instituted to aid the warriors of her country, will long excite a generous condolence. The zeal displayed by other females in this polished nation, has a strong claim for admiration. Their glorious occupations cannot be too frequently held up for imitation. They deserve to be followed by "the fair ornaments of the western world." May the bright examples of the daughters of America grow brighter still! may their success establish their rank in the intellectual world, while it creates blushes of shame and weakness on the cheeks of those men failing to walk in their ways!

THE time is now come, when the citizens of America should act entirely for themselves; when they should forever cease to depend on the caprice of foreigners, for the innumerable chemical compounds. This fair portion of the civilized world, to have its beauties enjoyed, and its excellencies duly appreciated, must in all its parts be adorned by native chemists. The dignity of independence and the glory of usefulness, should rouse the love of science from the lethargic dispositions in America. Animated by the noble emotions, her citizens would rally around the temple of fame, would become raised to the rank of a Newton, an interpreter of nature, and astonish the old world, as much by the sacred flashes of genius as by the purity of their political creed. The lights of science would then give a lustre constituting a new era in the annals of the creation. The same objects, truth and usefulness, would prove a connecting bond between every individual; and but a short time would then elapse, before it became the universal cry, that the road to science was the road to happiness.

NO individual can now do too much in promoting the study of chemistry. The call for immediate advancement throughout the republic is great. Ye free agents! ye guardians of the young! can you allow those under your care to neglect learning the principles of this all-important science? What then will you say, when arraigned at the bar of justice, before a Creator and an assembled universe, for neglect of duty! Your hoary locks will not cover you! the number of the accused will naught extenuate—and in vain will you deny the charge! The children of successive generations will rise up around you! In the face of heaven they will bitterly complain of the beauties to which they were insensible! while humanity, bewailing her misfortunes, will recount the number of blows she received, and the number of denials made to her call, because these creatures could not perceive the pleasures of her paths!

BUT, fellow-citizens, I really feel incapable of properly stating the beauty, the connexion, and the importance of the science of chemistry. For you to know these you must know the science itself. This understood, your souls would feast on the eternal beauties of nature, while you were inhaling the grateful incense arising from your services to the cause of humanity.

WARMLY wishing my countrymen the greatest success in their scientific researches, I shall now proceed to the detail of those principles and improvements which have been made by chemical philosophers——

——————" And truth shall be our guide,
Our golden theme, our glory to the last."

CONTENTS.

INTRODUCTORY ADDRESS, Page 17.

Containing an ennumeration of the connexions and importance of the science of chemistry.

DISCOURSE I, Page 41.

Containing general remarks, and a particular account of heat. To wit; definition of chemistry, properties of bodies, gravity; specific gravity distinguishes bodies form each other, means of ascertaining it. Attraction of cohesion, causing the form of bodies; crystallization; acts only between bodies of the same kind. Affinity, or chemical attraction; operates between bodies of different kinds, changes their properties and varies with the state in which bodies are placed, gives rise to many phenomena, &c. Page 45. Chemists discover that the bodies around us may be converted to certain states from which they cannot be further changed, in which they are called ELEMENTS, which variously combine and form COMPOUNDS, which are named according to the names of the constituents, page 50. The first element claiming attention, is called heat, or caloric; definition, it pervades all nature, it creates circumstances for changes to take place in bodies, as dilation or rarefaction; cooking; distillation; a still, page 54. Heat measured by instruments; thermometers, Fahrenheit's, Reaumer's, and Wedgewood's. It passes through bodies, more or less, quickly, and they are called good or bad conductors: metals good conductors, airs, coal, &c. the reverse; their use in preserving ice; remarks concerning the receptacles of ice; uses of the skins and clothes of animals. Heat unites to bodies and is called latent heat; produced by che-

E

mical changes, when absorbed, coldness is produced; means of producing great coldness by nature and art, page, 65. Means of exciting heat, most produced by Mr. Hare; theory of combustion, burning of volcanoes, detonation; production of rain, hail, and snow; heat of steam, used for cooking, machine for the purpose, page 73. Opinion of Dr. Black concerning heat, erroneous; proofs of the materiality of heat, page 75.

DISCOURSE II, Page 78.

Concerning Light, Electricity, and Galvanism. To wit; definition of light and some of the terms relating to it; refracted by some bodies; reflected by others, whose reflecting surfaces enable it to excite in us the ideas of color; vegetables bleached or whitened when light is prevented from acting on them; combines with bodies like heat; is extricated during chemical changes; solar phosphori; its influence on animals, vegetables, and other bodies, page 88. Electric fluid, called lightning; resembles heat and light in some particulars, combines with bodies, is extricated during chemical changes in the clouds, &c. is collected by an apparatus for experimenting, is carried off by metallic conductors; in its passage through air extricates the latent light of the air so as to cause a flash, page 91. Galvanism, page 92, resembles electricity, collected by the chemical action of oxigen on metals, page 93.

DISCOURSE III, Page 94.

Concerning the Atmosphere and Water. To wit; definition of aeriform bodies; examined by means of an apparatus; atmospheric air separated into two other airs, called oxigen, and nitrogen air; properties of oxigen air, it unites to bodies forming *oxids*, and also *acids*; their properties; means of collecting oxigen air; nitrogen air, its properties, method of obtaining it pure. When united in certain proportions, they form our atmospheric air; this air is frequently impure, the quantity of oxigen it contains ascertained by an eudiometer; contains fixed air and kills animals; contains infection; means of correcting or destroying it, page 105. Oxigen and nitrogen unite in different proportions, forming different compounds, page 104. They form the nitric acid, its properties; they form the nitrous acid, its properties; they form nitrous air, its properties; and also nitrous oxid, its properties. Water, page 116, ice; water; steam; water dissolves or chemically unites to bodies, is a most important agent, its boiling influenced by pressure of the air, freed from fetid impurities by means of charcoal, also by distillation, is found to be a compound formed of oxigen and an element called hidrogen; hidrogen air, its properties, means of preparing it.

DISCOURSE IV, Page 121.

Concerning Carbon, Sulphur, Phosphorus, and the Muriatic, Boracic, and Fluoric Acids. To wit; carbon, pure in the diamond; unites to oxigen forming carbonic acid, and to iron forming steel, prop rties of pure carbon or diamonds; they are in a strong heat in the presence of oxigen, converted into charcoal and carbonic acid. Plumbago contains much carbon, also common pit or stone coal, and charcoal or the remains of burnt vegetables, properties and uses of charcoal, it is a solid oxid of carbon; aerial oxid of carbon obtained from it, which is very inflammable; carbon unites in one portion to hidrogen air forming light carbonated hidrogen air, and in a larger portion forming heavy carbonated hidrogen air. When fully combined with oxigen it forms carbonic acid, or fixed air; properties of this air, it exists in great abundance in nature, water impregnated with it by means of Nooth's apparatus, united to other bodies it forms carbonates. Sulphur, page 131, how obtained, its properties, unites to oxigen in different quantities forming the sulphureous acid, properties of this acid, with a larger quantity of oxigen it forms the sulphuric acid, properties of this acid, elixir vitriol; united to other bodies it forms sulphates; sulphur unites to hidrogen forming sulphurated hidrogen air, its properties; sulphur unites also to the metals forming sulphurets, page 135. Phosphorus, how obtained, its properties, it unites to oxigen forming the phosphorous acid, its properties, in a larger quantity it forms the phosphoric acid, its properties; united to other bodies it forms phosphates, it unites to hidrogen air forming the phosphorated hidrogen air, its properties; it unites to the metals forming phosphurets. The muriatic acid, page 140, exists pure only in the form of air, how obtained, its properties; united to other bodies it forms muriates; it unites to oxigen forming the oxi-muriatic acid, its properties; used for bleaching bodies and purifying airs. Fluoric acid, how obtained, its properties; dissolves glass, united to other bodies it forms *fluates*, &c. Boracic acid, how obtained, its properti es; united to other bodies it forms borates.

DISCOURSE V, Page 145.

Concerning the Alkalies ; Ammonia ; Potash and Soda. To wit; general properties of alkalies; united to acids they form compounds called neutral salts. Of ammonia or the volatile alkali, its properties, how obtained; carbonate of ammonia or concrete volatile alkali, its properties and uses; muriate of ammonia or sal-ammoniac, its properties and uses. Potash or the vegetable alkali, how obtained, its properties and uses, it unites to sulphur forming sulphuret of potash. Carbonate of potash or mild vegetable alkali, its properties and uses; sulphate of potash or vitriolated tartar, page 152. Common nitre, saltpetre, or nitrate of potash, how obtained, its uses. Gunpowder, how made; fulminating powder, how exploded, page 155. Soda or the mineral alkali, how obtained, its properties and uses; carbonate of soda or mild mineral alkali, its properties and uses; common salt or muriate of soda, its properties, methods of obtaining it from sea water; nitrate of soda or cubic nitre, page 160. Glauber's salts or sulphate of soda, how obtained, its properties and uses, Phosphate of soda, how prepared its uses. Borax or borate of soda, where obtained, its uses. Concerning soap page 162. Soap of ammonia or volatile linament, how made; soap of soda or hard soap, how made, how adulterated; soap of potash or soft soap, how made; soap of wool, how made; general properties of soap, soap of lime.

DISCOURSE VI, Page 169.

Concerning the Elementary Earths. To wit; properties of earths in general; all the earths including stones, reduced to 9 different states from which they cannot be varied. First earth called silex, very abundant, forming rocks, &c. obtained pure, its properties, used to form glass, method of making various kinds of glass, page 172. Second earth, alumine, very abundant, forming the chief part of soils, of clay, &c. how obtained pure, its properties, unites to acids forming neutral salts, with the sulphuric acid, it forms *alum*, properties of this salt, how obtained for the purposes of commerce, page 175, alumine used for making *stoneware*, method of making pottery, queen's ware, china, and bricks, page 177. Third earth, lime, very abundant, how obtained pure, its properties, soluble in water, how to make lime water, unites to acids, with carbonic acid it forms chalk, marble, limestone, calcareous spar, &c. their properties, with sulphuric acid, lime forms plaster of Paris or sulphate of lime, properties of this compound, its uses; nitrate of lime, muriate of lime, fluor spar or fluate of lime, phosphate of lime, mortar made of lime, method of making mortar, improved highly by burnt bones, page 179. Fourth earth, magnesia, where found, how obtained pure, its properties; unites to acids, with carbonic acid it forms the uncalcined magnesia of the shops, or carbonate of magnesia, properties of this compound; with sulphuric acid this earth forms Epsom salt, or sulphate of magnesia, its properties; muriate of magnesia, &c. page 187. Fifth earth, barytes, where found, how obtained, its properties. Sixth earth, strontites, how obtained, its properties. Seventh earth, zircone, its properties. Eighth earth, glucine, its properties. Ninth earth, yttria, its properties.

DISCOURSE VII, Page 193.

Concerning the metallic bodies. To wit; general properties of metals, twenty two different kinds noticed—1 Mercury, where found, how obtained from its ores, its properties—when oxided, unites to the acids, red precipitate or nitrate of mercury, corrosive sublimate, or oxi-muriate of mercury, how prepared, its properties; converted into calomel, or muriate of mercury; properties of calomel. 2 Platina, where obtained, the heaviest metal, its properties. 3 Gold, where found, how purified, its properties; the arts of gilding. 4 Silver, where found, how purified, its properties; oxided, it unites to the nitric acid, forming nitrate of silver, or caustic, its properties; muriate of silver; art of silvering and plating, page 209,—

5 Copper, where found, how purified, its properties; nitrate of copper, blue verditer; sulphate of copper, or blue vitriol, its properties; verdigris, or acetate of copper, its properties; arseniate of copper: its alloys; tombac, brass, bell metal, &c. 6 Iron, page 218, where found, how separated, its properties; steel, how made, a new method, its properties, converted into iron; copperas, or sulphate of iron, its properties and uses: muriate of iron, flowers of steel, chalybeate waters; Prussian blue, or Prussiate of iron, how made; the prussic acid, its properties, &c.

DISCOURSE VIII, Page 229.

Metals continued. To wit; 7 Tin, where found, how obtained, its properties; making looking glasses, tinning iron and copper vessels; oxids of tin used for paints, united to acids, composition for dyeing scarlet, page 235. 8 Lead, where found, how procured, its properties; it unites to oxigen forming litharge, massicot, &c. its oxids unite to acids, sugar of lead or acetate of lead, muriate of lead, or patent London yellow, sulphate of lead alloys of lead. 9 Zinc, page 240, where found, how procured, its properties, nitrate of zinc, white vitriol or sulphate of zinc, its properties and uses. 10 Bismuth, where found, how obtained, its properties and uses. 11 Antimony, where found, how obtained, its properties and uses; glass of antimony, antimonial wine, tartar emetic, butter of antimony, James' powder, Kermes' mineral 12 Arsenic, where found, how obtained, its properties and uses. 14 Cobalt, where found, how obtained, its properties; forms a sympathetic ink, used to make zaffer smalt, method of making them. 15 Nickel, page 258, where obtained, its properties when pure. 16 Molybdena, where obtained, its properties. 17 Tungsten, where obtained, its properties. 18 Uranium, where obtained, its properties. 19 Titanium, where obtained, its properties. 20 Tellurium, where obtained, its properties. 21 Chrome, where obtained, its properties. 22 Columbium, where obtained, its properties. Recapitulation, but 46 simple or elementary substances found.

DISCOURSE IX, Page 272.

Concerning some of the productions of the Mineral Kingdom. To wit; water of the sea, its constituents. Mineral waters, page 275, their constituents, art of decomposing them, &c. minerals divided into 4 classes. *Stones* divided into 9 heads, bearing the names of elementary earths. *Salts*, not numerous. *Combustibles*, several kinds, sulphur, diamond, bitumen, page 285, naptha, petroleum, mineral tar, pitch, maltha, asphalt, elastic bitumen, pit coal, several kinds; jet, canal coal, common coal, amber, plumbago, their properties, &c. *Metallic ores*, arranged under twenty-two heads, &c.

DISCOURSE X, Page 295.

Concerning Vegetable Substances. To wit; general remarks concerning vegetables, their composition, reduced to sixteen different states, in which they are called proximate principles. 1 Wood, or ligneous fibre, its properties, means of preserving it. 2 Acids, seven kinds, citric acid, or acid of lemons, malic acid, or acid of apples, gallic acid, or acid of galls, benzoic acid or acid of benzoin, tartareous acid and acetic acid or acid of vinegar; means of preparing these acids, their properties; of making good ink, cream of tartar, of the process for forming vinegar or acetous fermentation; of the acids of cork, amber and camphor. 3. Tannin, page 305, how obtained, its properties; used to tan leather. 4 Oils, two kinds; expressed oils, oil of olives, linseed oil, castor oil; method of obtaining them, &c. Essential oils, how obtained, their properties. 5 Gluten, how obtained, its properties. 6 Fecula or starch, how obtained, its properties; method of making bread. 7 Indigo, how obtained, its properties, &c.

DISCOURSE XI, Page 322.

Vegetable Substances continued. 8 Sugar, how obtained, its properties; syrup, ferments and is changed to alcohol or ardent spirit, wine, porter or beer, cider, &c. Of ardent spirit, or alcohol obtained by distillation, its properties, means of ascertaining its purity, unites to acids forming ether; preparation of sulphuric, nitric, acetic and phosphoric ethers, how they are made, their uses, &c. 9. Gum or mucilage, its properties. 10 Resin, their properties; form varnishes when dissolved, art of making the different varnishes; of balsams, page 340. 11 Extract, its properties. 12 Elastic gum or Indian rubber, its properties. 13 Camphor, its properties. 14 Wax, its properties; how bleached. 15 Bitter principle, its properties. 16 Narcotic principle, its properties. Putrefaction of vegetables, page 347. Recapitulation.

DISCOURSE XII, Page 351.

Concerning the growth of vegetable bodies. To wit; plants grow from seeds, which combine with their food contained in the earth, which is converted into sap that circulates through them; theory to explain these phenomena: of the laws of plants; their functions, &c. 360. Of the food of plants; of soils; of manures; their manner of operating, the best kinds, &c.

DISCOURSE XIII, Page 372.

Concerning animal parts. To wit; of substances which are found in abundance in animals. Of gelatine, its properties; of glue, of size, of isinglass, their uses, &c. Of albumen or white of eggs, of fibrina or the coagulating part of blood; of oils, spermaceti, fat, train oil, animal oil of Dippel, their properties, uses, means of purifying them, &c. Of ambergris, page 384, of castor, of civet, of sugar of milk and of urine; of cantharides or Spanish flies, cochineal, gum lac, &c. Of animal acids, the Prussic acid, lactic acid or acid of milk, sebacic acid or acid of fat, uric acid or acid of urine, amniotic acid. Of the hard parts of animals, p. 390; of bones; of horns, nails, scales, muscles or flesh; means of preserving it from putrefaction; of skins, membranes, tendons, ligaments, glands, brain, nerves, hair, feathers and silk; method of bleaching silk.

DISCOURSE XIV, Page 404.

Concerning the fluids of animals. To wit; of blood, its separation into a clot, and a fluid called serum, used in clarifying liquids, &c. Of milk, its quantity, how increased, its cream; of butter, how increased in quantity and purity, means of preserving it from rancidity; of whey, its properties and uses; cheese, the method of making the best; of the milk of women, asses, goats and ewes; mares' milk; of bile, its qualities, composition, uses, &c. page 420. Of the gastric juice, or secretion of the stomach, its qualities, coagulates milk, useful to mix with medicine, &c. Of urine, page 425, its qualities, composition, state in disease, &c. Of poisonous secretions; of saliva.

DISCOURSE XV, Page 433.

Of substances which nourish animals; of the conversion of food into chyle, chyle into venous blood, venous blood into arterial, arterial blood into secretions, &c. principles on which these changes depend; putrefaction of animal bodies. Of coloring bodies, page 445; principles on which the art depends; division; bleaching; dyeing; articles necessary; dyeing Tyrian purple and scarlet.

CONCLUDING ADDRESS, Page 453.

Recapitulation of principles; what may be expected from the prosecution of the science.

DEFINITION OF CHEMICAL TERMS, Page 465.

TO THE READER!

Several very material typographical errors have most unfortunately escaped an earlier detection, in consequence of parts of the work being unusually *hurried* through the press. Such as do not change the sense are not of consequence, but the reader is particularly requested with his pen to correct the following :

Page.	*Line from the top.*
51	12th, for *unexceptionable*, exceptionable.
123	18th, for *Barneo*, Borneo.
171	11th, for *grantie*, granite.
183	last line, erase *on.*
195	12th, for *allays*, read alloys.
do	15th, for do. do.
216	8th, for *states*, strata.
222	26th, for *corburet*, carburet.
226	21st, for *disposition*, deposition.
236	11th, for *molydate*, molybdate.
241	1st, for *confined*, combined.
246	15th, for *a nitrous*, an.
250	14th, for *antimony*, arsenic.
268	2d, for *red*, white.
270	1st, for *phosphorus*, phosphorous.
302	14---15th, for *of being*, of not being.
308	10th, for *tar*, tann.
392	10th, for *Gibraltar do*, Gibraltar they do.
396	last line, for *is much exercised*, are much increased.

DISCOURSE I.

BEFORE treating of particular substances, it will be proper to offer some general observations, with which beginners should make themselves acquainted, although they may appear uninteresting.

THE object of chemistry being, to ascertain the properties or qualities, or laws of matter; it follows, that every thing around us, commencing with the air, and ending with the earth, are the subjects of chemical research. A correct knowledge of their laws or properties, can only be acquired, by noticing the changes produced in the bodies, in the various circumstances in which they are placed. In order to notice these, one substance is applied to another, in the state which experience has shewn to be proper for changes to be produced. This application of one body to others, is called an *experiment*, operation, or chemical process. "Chemistry, therefore, consists," says the perspicuous writer, Mr. Accum, "in a detail of those facts, which are founded on experiments and observations. Its basis is experience; from this, by regular conclusions, it deduces principles or theories; and connects a series of established facts into a certain order, called a system."

IF we elevate a body from the earth, on taking away the support, it immediately falls down. This return to the earth, is an effect produced by a cause, which, although not known, is designated by the term *attraction of gravity*. It is, therefore, by the attraction of gravity, or a law of matter, that bodies tend towards the earth; and on the same depends their adherence to it. We find, that one body adheres much more strongly to the ground than another; or in other words, has more weight or gravity. This is in consequence of the attraction of one to the earth, being much stronger than that of the other. For example, it is more difficult to raise a lump of lead of a given bulk than an equal bulk of cork; because the lead is more powerfully attracted by the earth than the cork, on which the weight or gravity depends. It is in consequence of this attraction of gravity, that the rain and snow descend---and that all fluids move until their surfaces are even; whereby the great falls of water, currents of rivers, runs, &c. are occasioned.

AS bodies of equal bulk are found to differ so materially in their weight, advantage is taken of it, for the purpose of distinguishing them from each other. The weight of pure water is considered as a standard by which that of other bodies is determined. The weight of a given bulk of this, say one pint, being ascertained, then the weight of an equal bulk of other bodies is to be found out, which when done, the weight of the water is to be deducted from it, and the difference is called *the specific gravity of the body*. Commonly the weight of water is expressed by the number 1,000, and that of other bodies in proportionate numbers. The specific gravity of bodies heavier than water, is best ascertained by weighing them in it. By this it will be found that the heaviest body known, *platina*, has a specific gravity, 20 times greater than water; that the specific gravity of lead is about 11 times greater; and so a great variation in the specific gravity of most bodies will be noticed. The body whose specific gravity is least, appears to be an inflammable air, which is 13 times lighter than atmospheric air; which last is 910 times lighter than water.

AFTER noticing the adherence of bodies to the earth, and attending to the cause called attraction of gravity, which was found to operate with various degrees of force, we next observe the forms and consistencies of the substances around us---varying from the extreme hardness of a stone, to the softness of jelly; and from the fluidity of water to that of airs. These different forms and consistencies, proceed from a cause, which is designated by the term, *attraction of cohesion* or aggregation.

CONCERNING this attraction of cohesion the following is known: it exists very strong between two particles of matter of the same kind. Hence, if you bring two drops of water near each other, they unite and form one drop. It is to this cause, that small quantities of fluids have a globular appearance, as rain, when no opposing force prevents. In other cases, this attraction of cohesion, causes the particles of a body to assume a particular regular shape, of several sides, as saltpetre, or common salt, or stones. This is termed *crystallization*, as the bodies so formed are sometimes like crystals. It should be recollected, that the exercise of the attraction of cohesion never alters the nature or qualities of substances; it only serves to give them shape, to preserve and increase their bulk. The force of this power, or the degree of cohesion, is diminished by increasing the distances between the particles of matter; and by this separation the cohesion may be entirely destroyed.--- Hence when it is designed to lessen it in a hard body, so that it may be fluid, or destroy it so that it may be powder, then a mechanical force, stronger than the attraction, must be applied. For this purpose, heat or fire, which enlarges bodies, is applied in many cases. Metals, wax, tallow, &c. when heated so as to melt, have their fluidity, in consequence of this, that their particles are separated by the heat, so as to lessen their cohesion; and, in consequence of the same diminution of cohesion, mercury, water, and other substances, are converted into steams or airs, when the heat is still more increased. In the first instance, bodies are said to be melted or fused; such are called *fusible* bodies, and those we cannot melt are termed infusible. Wh n it is intended to powder hard substances, or in other words, to divide them into their integrant parts, then other mechanical forces are used; such as grinding, cutting, filing, rasping, pounding, breaking, &c.

ON extending our general examination of bodies, we find, that some have a remarkable tendency to unite with others of a dissimilar kind, by which a most material alteration in the properties of the substances is effected. Thus we find, that iron will unite to air, and become rust, so as to lose its metalic properties: that an acid, as vinegar, will unite to the alkali, called potash, and form a compound unlike either of the ingredients: that sulphuric acid unites to lime, and forms plaster of Paris, a compound possessed of none of the properties of its constituent parts: that fat, or oil, unites to an alkali, and forms soap, a substance possessed of new properties, and so forth. All such changes arise from a cause—another kind of attraction, called *affinity*, attraction of composition, or *chemical attraction*. This must appear very different from the attraction of cohesion; for, the exercise of the attraction of cohesion does not alter the nature or qualities of bodies, and this invariably does. When the affinity between any two substances is exercised, the body formed is called a *compound*, or chemical mixture ; and, the substances forming it are termed its component or constituent parts, to distinguish them from the integrant parts of a body ; by which is only meant, a portion of a mass. Two substances may be intimately mixed with each other : but, however intimate this mixture be, it still consists of dissimilar parts, which may be separated from each other by mechanical means. We may mix mud with water, and they may be separated by mechanical means ; but if salt be added, then the salt and water chemically combine, and can only be separated by chemical affinities. The smallest integrant part of the compound will be found composed of a part of each ingredient, or constituent part. The only way to disunite or decompose them, is by the action of a *stronger* affinity than that uniting them together. Before the exercise of the affinities of bodies are changed, it is necessary that the attraction of cohesion should be destroyed. Hence heat, light, electricity, galvanism, and any thing which lessens the cohesion of bodies, are found to favor the exercise of the affinities of substances for each other.

BEFORE an affinity can be exercised, it is necessary that the state or circumstances for its exercise should previously exist. We know, for example, that the attraction of gravity does not operate on a body we elevate, so as to bring it to the ground, unless the cause of the elevation be removed ; when done, the circumstances for the exercise of the attraction exist, and, consequently, the body falls to the ground. Just so with the affinities of bodies; the state for their action must be created before they can be exercised.

THE attraction of gravity produces always one uniform effect; and that is, bringing bodies to the ground. But not so with the affinities of substances. *The affinities of a substance, are found to vary very much with the circumstances in which the substance is placed; although they are always the same in the same circumstances.* For example; two substances, called nitrogen and oxigen, will, by means of a large quantity of electricity, unite together and form a fluid: the same fluid (the nitric acid) in a high degree of heat, is converted into airs; again, iron, in one state, will remain pure; in another it will unite to air, and become rust; in one state it will be solid, and in another fluid; and the same may be said of most substances in nature.

THE circumstances, or condition or state, in which the affinities of bodies are exercised, vary prodigiously. All of them, no doubt, depend on a certain mechanism, or arrangement of matter, which cannot be described. We know, that heat, light, electricity, galvanism, and sometimes, other fine substances, are instrumental in creating the state or circumstances in which the affinities of a body are variously exercised. Such is the nature of these states, that we can only form an idea of their existence, by the formation of a compound, or exercise of those affinities of a body peculiar to the state; nor are we able to say *in what* one state differeth from another. All we can do is, to give the fact. Chemists should be particular, however, in mentioning what appears to create the state, when they notice the exercise of the affinities of substances. For example, they should mention, whether it was light, or heat, or electricity, and so forth, which seemed chiefly instrumental.

BY the exercise of the affinities of substances, chemists have ascertained, that the bodies around us, compounded, or formed by the chemical union of other bodies, are very numerous. They have ascertained this by two methods; the first is called *decomposition*, or analysis, by which is meant, not the division of a substance into integrant parts, but the separation or disunion of its constituent parts from each other: the second is called *re-combination*, or synthesis, by which is meant the union of the constituent parts of a body together, so as to form the same substance they did previous to decomposition. In order to re-combine or form again a body, it is only necessary, to add together the substances into which it was decomposed. But, to decompose a substance, it must be subjected to the exercise of an affinity, stronger than that which caused its combination. For example, if to the compound called chalk, (which is composed of lime and carbonic acid) you add sulphuric acid, a decomposition takes place. By virtue of a superior affinity the sulphuric acid unites to the lime, and the carbonic acid is disengaged in the form of air; which, while escaping, causes that motion called *effervescence*. But, when we add together two compounds, as Glauber's salt, which is composed of sulphuric acid and soda; and the nitrate of lime, which is composed of the nitric acid and lime, then the affinities of each of the substances are exercised. The sulphuric acid unites to the lime, forming plaster of Paris, or sulphate of lime, while the nitric acid unites to the soda, forming the nitrate of soda. Decomposition so effected, is said to be by compound *attraction*.--- Tables, shewing the relative attractive powers of bodies, have been formed, and are of great service in refreshing the memory. When decomposition is effected through the agency of water, it is said to be done in the *humid way*; when without the water, in the *dry way*. When a solid body is added to a fluid, for which it has an affinity (or tendency to unite) the two unite together and form a substance---not like a mixture, in which one body is merely suspended in another, but a chemical compound; for, very frequently, the bulk of the fluid is not increased by such combinations. In this case, the solid body is said to be in a state of *solution* or dissolved in the fluid, and when no more of the solid can be dissolved, it is called a *saturated solution*. If to this solution, you add a substance for which the fluid has a stronger affinity than it has for the one it contains, then they unite together, and the first falls to the bottom. In this case, the substance falling down, is said to be *precipitated;* and that which caused it is called the *precipitant*. For example, if to a saturated solution of saltpetre in water, you add pure spirit, for which the water has a stronger affinity than it has for the saltpetre, then they unite together, and the saltpetre falls to the bottom, or is *precipitated;* and the spirit is called the *precipitant*. When a solid is disengaged, and rises up in vessels, it is said to be *sublimed*. But, if it be a fluid, it is said to be *evaporated*, or *volatilized*, which if condensed in vessels, is said to be distilled.

CHEMISTS have reduced all the variety of compounds around us into a few bodies, which they cannot further reduce. These, which they cannot further decompose, are called simple or elementary bodies; and of course all the bodies around us are compounded of these few simple substances or elements. Formerly chemists guessed that every thing was composed of five or six elements; but, by the modern method of reasoning from facts which are ascertained, it appears that there are about forty-five simple or elementary substances, which they cannot further decompose Of these, are heat, light, electricity, galvanism, carbon, phosphorus, sulphur, iron, silver, gold, copper, &c. &c. &c. It is probable that several of the substances, now considered as elementary, may hereafter be shown to be compounded; but this is only common conjecture, which should not be credited till established by experiments.

To give correct names to the elementary and compounded bodies has occupied much of the time of modern chemists. It was proposed to name the simple substances, from some striking quality which they possessed, unless it be forbidden by constant custom. For example, there is an air remarkable for forming nitre or saltpetre; this is therefore to be called nitrogen air. Substances compounded of others it was proposed to name after their component parts. For example, Glauber's salts are composed of sulphuric acid and soda, and are therefore called sulphate of soda. By this it was expected to avoid the various and whimsical denomination of substances by different persons, and also to favor the memory in recollecting the constituents of a body when it was called. On this is founded the *new nomenclature*, which has made so much noise in the world of late years; and which is, beyond all doubt, of great value, if not abused by the alterations of too many innovating and obtruding hands. Every one should learn something concerning it. The great French chemist, Mr. Lavoisier, speaking of this, observes, that "the impossibility of separating the nomenclature of a science from the science itself, is owing to this, that every branch of physical science must consist of three things; the series of facts which are the objects of science; the ideas representing these facts, and the words by which these ideas are expressed. Like three impressions of the same seal, the word ought to produce the idea, and the idea to be a picture of the fact. Now, as ideas are preserved and communicated by means of words, it necessarily follows, that we cannot improve the language of any science, without at the same time improving the science itself; neither can we, on the other hand, improve a science, without improving the language, or nomenclature, which belongs to it. However certain the facts of any science, and however just the ideas we may have formed of these facts, we can only communicate false or imperfect impressions of these ideas to others, while we want words by which they may be properly expressed."

BESIDES the general laws of matter, the attractions of gravity and cohesion, and chemical affinity, philosophers have considered another, called *repulsion*, by which different bodies are kept apart. The cause of the separation of such bodies is a mechanical one, as in most cases will appear evident; and consequently, it would be improper to conclude there was a repulsive principle.

Having premised these general observations, I proceed to consider the particular substances around us, and first of the four, named *heat*, *light*, *electricity* and *galvanism*, which are termed *unconfinable elementary bodies*.

CONCERNING HEAT.

BY heat is meant, that which excites in us the idea of warmth or hot, and when the quantity is lessened, the idea of cold. In common language, bodies are said to be hot and cold; yet the sensations we have on touching them, do not arise from the bodies, but from the passage of heat into and out of us. Heat is supposed to be a subtile substance, flying off from bodies in the finest rays. By some common people it is called fire, particularly when accompanied by the emission of light, as in a blaze; by others it is called heat; and chemists to avoid confusion, call it *caloric;* by which they mean *that* which excites the sensation of heat.

OUR attention is early claimed by the changes which take place in bodies, when heat is accumulated. These changes are generally termed the effects of heat; but, as some of them are not produced directly by the heat, but by the *affinities* of bodies exercised in the circumstances created by the heat---the expression appears to me unexceptionable. Perhaps, however, in common language, it may not be amiss to use it.

In most cases, heat separates the particles of bodies from each other, thereby lessening the attraction of cohesion, and increasing their bulk. The following experiment will convey an idea of the expansion which takes place when heat is increased: if a bladder half filled with cold air, be carried near the fire, the air immediately expands, distends the bladder, and bursts it finally with considerable force. It is to this expansion, or rarefaction of air, by which its weight is so lessened, that it ascends in the air, in consequence of the pressure of a denser air, that the currents of airs about fires, and the various winds are produced. If a bar of iron, which while cold, precisely fits an orifice, be heated, the enlargement will be so considerable that it will not re-enter the hole. By making a bar of iron six inches long, red hot, its increase of bulk, will be one twentieth of an inch. All bodies, however, do not expand alike. Liquids of the least density expand the most in the same temperature. Thus, atmospheric air will dilate more than ether, this more than ardent spirit, this more than oil, this more than water, this more than acids, and these more than mercury. Hence articles which are sold in commerce by measurement, particularly spirit, are often found much smaller in quantity in winter than in summer. By the expansion of metals, cutting instruments are rendered sharper when heated; and clocks and watches vary in keeping time, in consequence of the different expansion of their metals, in cold and hot places and seasons. As different metals expand differently in the same heat, such musical instruments, whose parts are to maintain a constant and true proportion, should never be strung with different metals, as on this account they may be out of tune. Bodies which are brittle, as glass, crack or break if suddenly heated or cooled, in consequence of this, that the expansion, on one side, by the heat, is so great as to tear apart the other: hence thin vessels stand heat better than thick ones.

The enlargement of bulk is not the only effect which takes place in an increased temperature. Other and more important changes are produced in many substances, by the exercise of their affinities in the states created by heat. A few substances when heated, become *melted* or *fused*, and all such are termed *fusible*. In a higher heat many are converted into finer fluids, called vapors, airs, or aeriform bodies, such are called *evaporable bodies*. We have a striking example of this in ice; which in a heat above 32° is *fused*, or changed into water; and this fluid in a heat above 212° is evaporated, or changed into vapor or air. The degree of heat necessary to create that state, in which bodies assume the aeriform state, depends in some instances very much upon mechanical pressure. Hence we find, that when the pressure of our atmospheric air is lessened, as it is on mountains, or in the exhausted receiver of an air pump, fluids may be made to boil, or change to vapor, in a much lower heat. The diminution of the bulk of a body, in a low heat, is not less general than their enlargement in a high heat. Hence on conveying vapors in a cold place, as in the tube passing through the tub of a distillery, they are condensed into fluids. Perhaps, in most intense heats, all bodies might assume the aeriform state; and perhaps if all heat could be abstracted, all the airs and fluids around us might become solid.

In the art of cooking, heat acts by its instrumentality in lessening the cohesion of the food, thereby rendering it more nourishing, and allowing other and more palatable combinations to take place between the various articles the cook blends together. It would be too disgusting to detail the various compounds which have been made by cooks for their idle masters. But it may be observed, that heat has a most remarkable effect in increasing the capacity or power of water to dissolve substances, as we daily see in the boiling pot, where soops, jellies, &c. are made. This capacity is greatly increased when an instrument which confines the steam is used, called Papin's digester. When this is made very tight of strong iron, water may be heated in it more than 100 degrees beyond boiling water. In this state it will dissolve all animal parts; and so excellent a soop may be made from bones, that it would be well for all families to be provided with one, as it would save much expence in the course of a year by superseding the use of much meat. In consequence of the action of heat on vegetables in water, whereby they are rendered more nutritious, Count Rumford judiciously proposes to boil all the food given to domestic animals, as much smaller quantities would then suffice.

In the art of distilling, heat acts also an important part; it favors the separation of the volatile substances, as spirit, essential oil, &c. from their combinations; and it is probable, that it causes the chemical combination of the particles of the mass, so as to form the substance distilled in some instances, and in others lessens or destroys such a combination. Hence, on distilling some fluids, which are not very intoxicating, a good deal of spirit is procured; but on distilling a more intoxicating liquor, as wine, but little spirit will be obtained. Yet, this spirit is said to give the intoxicating qualities to all drinks. It would be well for distillers to try in what heat they can procure most of the substance they distil. The best plan on which a still could be erected, is that represented in plate 1 fig. 1. A, is the body of the still of various sizes. It should be covered with mortar three inches thick, made of equal quantities of clay and fine charcoal; and then placed in bricks. The fire is applied underneath, but the flue turns round in a spiral manner, as shown by the dotted lines; by this means but little heat will be lost. B, The head of the still, provided with an opening at *o*, to let out the vapor when in danger of throwing the head off; the body has also one at *u* to supply the fluid. The head should be made of two thin sheets half an inch apart, between which should be air, ashes, or fine charcoal, which will prevent the loss of heat. C, the *refrigeratory*, or *condensing tub*, filled with cold water, through which the worm marked by dotted lines passes. The vapor from the head, is condensed in this worm, and runs out at the vessel D.

THE means to ascertain the degree of heat present, are now to be mentioned. For this purpose, instruments have been contrived, called thermometers, which are in common use. Fig. 2, plate 1, represents one of the best kind, called Fahrenheit's. The way to form one of the kind, is to procure a small glass tube, the bore of which is perfectly regular, to melt one end in the blaze of a candle, then to blow it at the other end, so that a bulb may be formed. this being done, the tube is to be filled with spirits of wine, colored; or what is better, mercury. If mercury be used, after filling the tube, it is to be boiled for the extrication of all air. The other end of the glass should then be sealed, and the whole introduced into freezing water. Here the mercury parts with its heat, and consequently contracts, or sinks down to a point which should be marked, and named as in the plate, *the freezing point.* Afterwards the whole should be introduced in water boiling under the common pressure of the air. The heat of the water, will enter the mercury, and consequently expand it up to a certain height, to be marked as the *boiling point* of water. Now the space between these, is to be divided into equal portions, on a body attached to the glass. The number is not of much consequence. The French use Reaumur's scale, and the English Fahrenheit's, both of which are represented in the plate. Fahrenheit's scale at the freezing point is marked 32°; at the boiling point 212°. The mercury in the tube will rise or fall in proportion to the increase or diminution of heat. In Fahrenheit's scale (which will be alluded to throughout this work, while mentioning degrees of heat) the heat of the human body will raise the mercury to about 98°. That of a summer's day, in the district of Columbia, where I am about to reside, from 70° to 90°. In mild weather the mercury stands at about 50°. In winter it varies from 25° to 40°. At Hudson's bay, and in Siberia, the mercury has become frozen, and sunk near 80° below the freezing point.

By the above thermometer no heat greater than that of boiling water can be detected. To remedy this, an instrument was invented by Mr. Wedgewood, called a pyrometer. It consists of two pieces of brass, fixed on a plate, so as to be six tenths of an inch asunder at one end, and three tenths at the other. Bits of baked clay, previously prepared in a red heat, are made of given dimensions. These pieces of clay are first applied to the rule of the above gauge, that no mistake may be made. Then one of them is to be introduced into the heat which is to be measured, when it will *contract* in proportion to the intensity of the heat. It is then to be taken out, and on applying it to the gauge, its contraction will clearly appear, and thereby indicate the degree of heat to which it had been exposed. Each degree, which it may have shrunk, is equal to 130° of Fahrenheit.

HEAT penetrates all bodies in consequence of its strong tendency to be equally distributed, or establish an equilibrium. Such is this tendency that no one has been able to abstract all the heat from any thing. It has been stated that the attraction of cohesion brings the particles of bodies together, which is an effect, the reverse of that caused by heat. Now as bodies generally diminish in bulk, in proportion to the abstraction of heat; and as we cannot abstract all the heat from any thing, it follows as an unquestionable, though singular conclusion, that no two particles of matter do ever touch each other. It is in consequence of this tendency of heat to be equally distributed, that if a hot and a cold body be brought near each other, the temperature of each soon becomes the same. Hence we go near the fire to be warmed, and go in the cold to part with heat.

THE changes in the temperature of bodies occupy a longer or a shorter time according to the nature of the body; but they always take place at last. The bodies which do not reflect much heat from them, but allow it to pass through them quickly, are called *good conductors* of heat; and those reflecting the heat, so that it penetrates but slowly, are called bad or *non-conductors* of heat. Thus it is said in common language, that some bodies are warm, or retain the heat, and others are cold, or carry it off rapidly. Thus if we introduce our hand in mercury, and in water of the same temperature, the mercury will feel coldest, as it most quickly conducts the heat of the hand. Hence, if we put the ends of two rods in the fire, of the same dimensions, one of glass and the other of iron, the other end of the iron will soon be too hot to be held in the hand, while the glass will scarcely be warmed.

DECISIVE experiments have shewn, that of the solids, the metals are the best conductors of heat, and the conducting power of these are also found to differ from each other. Gold, silver, copper, iron, tin, &c. are found the best conductors; and next to these stones. The good conductors of heat are used, when it is designed that heat should be communicated to other bodies for boiling, warming rooms with pipes, &c.

THE bad or non-conductors of heat, are numerous and useful. Very decisive experiments have shewn, that atmospheric air, particularly when confined and dry, and all other airs, ashes, charcoal powdered alone and mixed with other substances, feathers, skins of animals, and coverings of vegetables, straw, cotton, hair, eider down, raw silk, sheep's wool, lint or the fine scrapings of linen; and indeed all fine substances which retain the atmospheric air about them are excellent non-conductors. By attending to this subject, important advantages may be derived, which are unknown in most places.

In very cold countries, they have in some parts, windows with double panes of glass, the one half an inch before the other; the air between them proves of great service in preventing the exit of the heat from their rooms. The same, probably, it would be well to do in hot countries, which would prevent the entrance of heat. It would probably, also, be still better to have a column of air confined under the coverings of the house, and around the rooms behind the plaster. Vessels of iron and tin made of two thin sheets, the one half an inch or two inches from the other, are found very useful in cooking, in consequence of not allowing the escape of heat. They would be still better, particularly the tops of stills, if fine charcoal or ashes were introduced between the sheets. Our amiable fellow-citizen, Mr. Moore of Maryland, has made some excellent remarks concerning the application of this knowledge, to the construction of the receptacles of ice, by which a given quantity of ice may be preserved from melting longer than one would readily suppose. A tin vessel, about two feet square, placed in a wooden one so much larger, that a space of 3 or 5 inches may be left all around, with this space filled up with charcoal, ashes, hair, or broken glass; will be found to answer exceedingly well to retain ice during the day for family purposes. The top of this cooling vessel (or refrigerator) should be made in a similar way, and to fit tightly. In the middle of it, a small lump of ice should be placed in a cup; and at the sides of the cup, the butter, milk, meats, &c. may be preserved all day as cold as ice, when the vessel is closed. By using such a vessel, a very small quantity of ice will serve a large family, during the hottest days. Ice houses should be made in dry situations : the inner walls should be of wood charred or burnt to coal, all over, at the back of this, a space filled with air alone, from 1 to 2 feet thick, or dry straw, ashes, or a mixture of equal parts of clay and charcoal with it. An ice house 10 feet square thus made, will preserve ice, longer than the largest under common circumstances.

A cheap mortar may be made of about equal parts of charcoal and clay, which is an excellent non-conductor of heat. Chimneys lined with this, and surrounded also by a column of confined air, or ashes, or pure charcoal, and made after the manner suggested by Dr. Franklin, and generally called Rumford's chimneys, would be beyond all further improvement. In an iron stove lined with the above mortar 2 or 3 inches thick, a greater heat may be generated by the combustion of but a small quantity of fuel, than could be contained in it by any other means, without such a lining. The inner part will be found red hot, before the outer part is warmed. Persons wishing to reduce ores to their metallic state, might readily provide themselves with a small common stove, and line it as above. They could readily cause a sufficient heat to be generated in it, to decompose and change to the pure metallic state, the most infusible ores. Or if the blow pipe be used, it might be made to act on the substance much better, when they are surrounded by such a mixture. This mixture would be of great service for covering the body of stills, lining furnaces, ovens, brick-kilns, and all places designed to retain heat. Great quantities of fuel would be preserved by attending to these facts.

Wood, green or charred over, is a remarkable non-conductor of heat; and hence it is proper to have instruments used about fires with wooden handles. Count Rumford has proved that barks of trees, peelings of fruit, are remarkable non-conductors of heat. This accounts for their not losing their heat in cold weather, which was formerly attributed to a vital principle. The snow covering the ground in winter, no doubt is useful in preventing the loss of heat from the roots of plants beneath. The skins and furs of animals being most excellent non-conductors of heat, it accounts for their preservation of the warmth of animals in very cold countries: those skins are warmest which have the finest, longest and thickest hair. Hence the beaver, otter and other quadrupeds, as well as water fowls, well feathered, retain their heat in the coldest times. Bears and other animals not frequenting the water, have the fur thickest on their backs.

The clothing of men is valuable chiefly on account of its retaining the heat of their bodies. Cotton and wool are better non-conductors of heat, than linen or silk, and consequently should be worn in winter. The scrapings of fine linen, are highly useful in retaining heat, and hence, are properly introduced in quilts. Such as are accustomed to sleep on hard bodies, and cannot purchase a bed and clothing, would probably sleep much more comfortably, if they would have a long case, open only at the end charred in the inner side, and lined with some cheap article, in which they could introduce their bodies, without fear of cold at night, keeping their heads out.

Count Rumford, in his essays on heat, states that all fluids are *perfect* non-conductors of heat; in consequence of noticing, that when heat enters them, a motion takes place, which one would naturally expect who knew the facility with which fluids could be agitated. However, it matters very little, since it is a fact, that heat passes through them. The Count found, that by introducing heated bodies into fluids, the heat was not communicated downwards; also, that ice melted 80 times more quickly on the top than at the bottom of hot water. This must appear very evident to any one knowing that heat rarefies bodies in which state they ascend. He thinks that he has discovered that the steam of water is a non-conductor of heat. That it is a non-conductor, might long since have been inferred, from the fact, that it requires much longer time, for a drop of water to evaporate from red hot iron than from that which is less heated. Hence it has been proposed, to ascertain the degree of heat present, by the duration of a drop of water on hot iron. Mr. Chaptal states, that the water is longest retained on the hotest iron, in consequence of a decomposition it is supposed to undergo. But this is erroneous; as, we perceive the water bouncing about in various directions. It appears to me, that the retention of the water can only proceed from the formation of steam underneath it, thereby preventing the heat from entering the inner part, and causing the drop to move in various directions. In this idea, I am supported by a fact, which occurred lately among some school boys. One of them heated a poker red hot, and then several times licked it with his tongue, to the great astonishment of the rest. Here the steam, suddenly formed between the tongue and the iron, prevented the heat from burning him. On putting down the poker, after it had lost the red heat, another of the boys, from the love of imitation or of showing his courage, took it up and repeated the experiment. The heat, not being sufficient to form steam, penetrated his tongue, and burnt him so as to make him bellow, to the no small diversion of the bystanders.

HITHERTO, I have been speaking of that heat which is free from combination, acts on our senses, and is consequently called free, uncombined, sensible, radiant, or thermometrical heat. Dr. Black of Scotland, made some important experiments, by which he discovered that this sensible heat was absorbed by some bodies, particularly when they were changed from the solid to the fluid state: when absorbed by bodies it chemically combines with them, so that it neither acts on our senses or on the thermometer. In this state it is called solid, combined, or *latent* heat. An idea of this may be formed from the following experiment: take a pot of water, allow it to remain on the fire, and constantly to boil. The heat will be continually imparted from the fire to the water; yet it will be found that neither the temperature of the water or of the steam will ever exceed 212°. Ice in a warm room will, while melting, absorb heat (or produce cold); yet its temperature will not be increased above the melting point 32° until the whole is melted. If salt and water, the temperature of each being the same, be added together, while the salt melts, there will be considerable coldness, or absorption of heat. The only manner in which this loss of heat, in these and similar experiments can be accounted for, is by its chemical union with the substances: it is therefore properly termed latent heat. As different bodies unite with different quantities of heat, their power of uniting with it is termed their *capacity for heat;* the whole quantity of heat uniting to a body is termed its absolute heat. The experiments to ascertain the absolute and specific heat of bodies, are neither accurate or of much consequence. It is *generally* true that all bodies, whenever their conditions or states, are in any manner changed, have a corresponding change in their capacities for heat. Hence they either give it up, which produces warmth, or unite to it, which produces coldness. When they are changed from the solid to the fluid, and from the fluid to the aeriform state, generally they unite to or absorb heat. That this is the case, is proved by the fact that they may be made to give up this heat again, as we see instanced in steam; which every one knows gives up heat when condensed to water, which last gives more up when reduced to the state of ice. *Generally* all bodies, when changed from the aeriform to the fluid, and from this to the solid state, give up sensible heat. However, there are striking exceptions to this, as some bodies undergo very material alterations without any change in their capacites for heat. All the changes in heat, with which we are acquainted, from the most intense heats to the extremes of cold, arise solely in consequence of the changes in the capacities of bodies for heat. The *means* of varying these capacities may be very properly considered in this place. And first, of diminishing heat so as to produce COLDNESS.

In nature we find coldness very generally produced by evaporation, as the fluids are changed into vapors, they absorb the sensible heat, and carry it off. The dryness and agitation of the air promote this evaporation very considerably. The coldness of summer days frequently arises from the sudden evaporation of water from wet lands, and it is in consequence of the evaporation of the sweat of laborers, (particularly the blacks, whose skin favor the generation of warmth, which promotes perspiration) that they are enabled to work in the hottest weather, exposed to the sun. The same evaporation, has enabled persons to remain minutes in rooms where the heat was sufficient to boil water all around them The scorching winds within the tropics, are prevented from suffocating travellers, only by covering their heads with wet cloths; which if too wet, will by the quick evaporation of the water, become insufferably cold. Sprinkling water on the streets, cools them on the same principle. In the East Indies, ice is frequently made in pits dug in large open plains, at the bottom of which, dried straw or stalks of Indian corn are placed ; upon these they put a number of unglazed pans, made of so porous an earth, that the water with which they are filled exudes through them. These pans are filled towards evening, in the winter, with boiled water, and are left tranquil till morning, when more or less ice is found in them. The quantity depends on the temperature of the air; there being more found in dry and warm weather, than in cloudy.

In Spain half baked earthen pans are used to contain water. Their outside is kept wet by the water which filters through them, and although they are exposed to the sun, the water in the jar becomes as cold as ice. I have thought that it would be very advantageous to have a wind machine, something like a Dutch fan, to cool our waters in summer. If at the mouth of such a one, tin vessels containing water and covered with wet rags, or unglazed earthen vessels, with the water exuding through them, were placed, and the dry air of the warm side of houses, caused to pass quickly over them, there is no doubt but that the evaporation would be such as to cause considerable coldness. Perhaps, ice might be made in this manner. At all events, our drinks might be so cooled as to supersede, probably, the use of ice-houses. In China it is common to cool wine and other liquors, by wrapping the bottles containing them in wet woollen rags, and exposing them to the sun. The blacks, in parts of Africa, have very cool water, in consequence of hanging it up in leather bags in the shade, where the evaporation becomes considerable.

On putting a little ether on our hands, we immediately have the sensation of cold, from its quick union with the heat of the hand. By inclosing water in a thin glass vessel, and dipping the glass in ether, and then moving it briskly to accelerate the evaporation, ice will in a few minutes be formed.

When some substances unite together, they acquire a capacity for heat, and absorb great quantities in some instances, so as to produce the most intense coldness. In the West-Indies, wines are generally cooled by introducing them into the following cheap mixture: Of Glauber's salts 16 parts, of saltpetre 10 parts, of sal-ammoniac 11 parts, and of water 32 parts. The coldness, after this combination, will be considerable; but not so great as that from the following, which are extracted from lists containing many others of the kind.

MIXTURES.	THERMOMETER SINKS.
Sal-ammoniac, 5 Nitre, 5 Water, 16 } parts.	From 50° to 10°.
Glauber's salts, 3 Diluted nitric acid, 2 } parts.	From 50° to 3°.
Equal parts of snow and common salt.	From 50° to 0°.
Equal parts of snow and diluted nitric acid.	From 0° to 46°.
Diluted sulph. acid, 10 Snow, 8 } parts.	From 68° to 91°.
Dry muriate of lime, 3 Snow, 2 } parts.	From 32° to 50°.

MIXTURES.	THERMOMETER SINKS.
Potash, 4 } parts. Snow, 3	From 32° to 51°.
Muriate of lime, 2 } parts. Snow, 1	From 0° to 66°.
Equal parts of snow and diluted sulphuric acid.	From 20° to 60°.
Muriate of lime, 3 } parts. Snow, 1	Fiom 0° to 73°.

Mercury may be frozen by all the mixtures, bringing the thermometer 40° below 0°. They are so cold that the hand is quickly blistered if introduced in them.

We are now to mention the means of generating heat. They may be divided into mechanical and chemical. The mechanical means operate merely by squeezing the sensible heat out of the body. By the sudden pressure of atmospheric air, heat may be extricated in sufficient quantities to burn some substances. Most of the metals may be made almost red hot, by hammering them quickly. In some places powder is flashed, by employing a strong man to strike an iron briskly till heated for the purpose. The heat following the friction of hard bodies against each other, appears to arise, in the first instance, from the sudden pressure of the surrounding substance. Flint struck against steel generates a heat sufficient to cause the steel to melt, which afterwards burns, as may be observed by catching the bits as they come off on paper. Fires are quickly kindled by rubbing dry sticks against each other in some parts;

an iron plate may be made red hot, if much pressed on another, and moved backwards and forwards. Carriages and mills, are sometimes set on fire by the heat collected during the turning of the wheels. Count Rumford made water boil by boring cannon in it.

THE chemical means of exciting heat, or in other words, the means of diminishing the capacities of bodies for their latent heat, are now to be considered. On collecting together the rays of the sun, by means of a lens, it is well known that great heat may be produced. Diamonds have been burnt by the heat so produced. This heat does not come from the sun, since it would require some time for it to penetrate the glass. It is, in all probability, caused by the union of light with the body on which it acts, whereby the capacity for heat is lost. On the same principle, great heat may also be created by the electric and galvanic fluids, so as to melt the hardest bodies.

Water may be made quickly to boil, if inclosed in a tube, which should be placed in a vessel containing water; to which water, sulphuric acid is to be added gradually. Spirit of turpentine will quickly blaze, if a small quantity of the nitric acid be poured on it. Many other combinations of the products of art, are characterized by the emission of heat, which it would be useless to mention in this place. Many combinations in nature take place, which are attended by the emission of heat. We frequently see it during the putrefaction of animal and vegetable matter in dung heaps. Stacks of hay are sometimes burnt unexpectedly by similar chemical changes. Particularly about volcanic places great heats are thus generated. Sometimes the earth, in parts of Italy, is so hot as to burn the feet of passengers.

And lastly, the burning of volcanoes arise from the same cause—a change of capacity for latent heat. It may not be improper here to observe, that the phenomena attending volcanoes arise, probably, from the chemical action taking place between iron, sulphur, and water. These three substances are common about volcanoes ; and by mixing them together at any time we find heat will be generated. What still more confirms this, is the artificial volcano which may be formed by these substances, and which exactly resembles in miniature the great volcanoes. If equal quanties, of the filings of iron and sulphur, be made into a paste with water, and from 30 to 100 weight of it be covered 5 or 6 feet under the earth, and well pressed down, in a few hours an action will commence : smoke and fire will arise, the earth will open and lava will be emitted.

It is chiefly by the combustion, or burning of bodies, that sensible heat is emitted for the common purposes of life. Every one knows that for this combustion to take place, the presence of atmospheric air is necessary. The sensible heat which follows the process, is probably given up by the body burnt, as well as the air which disappears. It cannot be accurately determined how much heat is given out during combustion. But it has been ascertained, that the largest quantities are yielded while an air, called hidrogen air, mineral coal, wood, &c. are burning. The largest quantity of heat, which has been yet produced, was by Mr. Hare, an ingenious chemist of Philadelphia. On learning, that most heat was thrown out during the combustion of hidrogen in vital air, he had a quantity of the two airs collected (the manner of doing which will be hereafter stated) and introduced them in a double bellows, each pure and in distinct apartments. The tubes, leading from these apartments, opened at the same place, where fire being applied, sufficient heat was generated to melt the most infusible metal, platina, and several substances, never before fused.

The theory, to explain what takes place during combustion, is perfectly simple. The reader should be apprised, that our atmospheric air, is compounded of two airs; that three fourths of it are of no service in supporting combustion, and that it is the remaining one fourth, called vital or oxigen air, which is the chief agent in the process.--- Now this vital air contains in a latent state great quantities of heat and light; the capacity for which is lost more or less when the air combines with other bodies. This being recollected, the following must appear more plain. Heat is applied to a body; it puts that body in a state in which it attracts the vital air; to which it unites, forming a new substance, which not having the capacity to retain the latent heat and light, the ingredients had previous to union, these are consequently set at liberty in the form of *blaze*. This is the general explanation of the process of combustion.

We will now consider more particularly the burning of wood. Fire is kindled at one part, the heat penetrates it, converts it into charcoal, and rarefies this charcoal into a kind of air. In this state, the air is quickly attracted, and an union follows, whereby heat and light are set at liberty. The heat continues to penetrate the wood, and creating the necessary state for its union with air, till the whole disappears. The rapidity of the process, is also increased, by the sensible heat, which rarefies the surrounding air; in consequence of which, it is quickly removed by the pressure of a denser air, which still more favors the chemical combination. The reasons then must appear evident, why there is a circulation of air about fires, and why it is indispensably necessary for a free combustion or union between the air and coal. Moderately blowing the fire, by pressing the air closer to the wood, promotes combustion; blowing it too rapidly extinguishes it, by carrying off the heat before it creates that state in the wood necessary for its union with air. Water extinguishes it, by carrying off part of the heat, in the form of steam, and by preventing the contact of air.

During the combustion of mineral coal, we perceive how necessary the agency of heat is to create that state, in which the substances in it capable of burning, exert their affinity for oxigen. We have, also, a striking illustration in the burning of a candle. In a little heat, the tallow first becomes fluid, then it is drawn up by the wick, where more heat existing it expands, and as rising unites to the air, thereby causing the blaze. Instead, therefore, of saying that combustion was the consumption of a body, we should define it, "the formation of a new compound, through the agency of heat, attended generally with the emission of heat and light."

When, instead of allowing a combustible body to burn slowly in the air, we add to it a substance, as common nitre, which contains a great deal of light and heat in the solid state, then on applying fire, the union is quick, and the emission of heat and light instantaneous. This heat rarefies the bodies so suddenly, and with such force as to produce a loud noise and great effects : this is called *detonation*. We have an example in the combination of sulphur, charcoal, and nitre, forming gunpowder. On applying heat, a chemical action ensues instantly, and is followed by the violent effects, usually noticed in consequence of the expansion of airs, by the sensible heat which it liberated.

Besides, by the above methods we have sensible heat, by the condensation of vapors. When we lay a cold body down in summer, it absorbs sensible heat from the water in the air, which then becomes condensed in the form of drops on the surface. It is, also, in consequence of parting with sensible heat, that we find water condensed on the windows and walls of houses. To the same cause, must be owing the collection of the vapors in the air, at first to form fogs, then clouds, dews, rain, snow, and hail. What becomes of the sensible heat in our atmosphere, when water is condensed, and what is the immediate cause of the condensation, must be interesting questions. It appears to me to arise from chemical changes in the air, which may be wrought by various causes, whereby the capacity of the air for latent heat becomes so increased, as to attract it from the water. Every one knows, that the electric fluid is collected in various quantities, at various times in the air; and that when it is present it causes the extrication of heat. Now, it is very probable, that in consequence of collections of electricity in the air, its capacity for heat is lost; then when the electricity escapes slowly, or in large quantities, causing thunder, the capacity for heat is restored to the air, which consequently absorbs the heat from the surrounding vapor, thereby converting it into water, or rain, hail and snow. Hence we see the reason, why in hot countries, lightning, rain, and hail so generally go together. Light has no doubt, also, some influence in lessening the capacity of the air for heat, as we know that heat is thrown out when light is collected. But to descend from clouds to pot-boiling, we have already stated that steam contained latent heat, which was given up or converted into sensible heat when it was condensed. Count Rumford has particularly attended to this, with a view to economise in the use of fuel. He proposes to have the steam conveyed through pipes, where it will condense, and give out the heat to which it united, during its conversion, for the purpose of cooking. Unquestionably this would be of great advantage. The steam from a small kettle of water is sufficient, if properly conveyed over the articles, to cook any vegetable or animal substance in common use. In some houses they have already got in the practice of using steam altogether; so that the boiling of one small pot serves for dressing all the meats, and most of the vegetables used in a large family. In common, it might answer to have an apparatus for cooking, on the plan of that represented in plate 1, fig. 3. A is a box, which should be three or four feet in length and breadth, and only one in height. It may be constructed of what materials the maker pleases to employ. It would answer very well to have it of thick plank, which has been *charred* or burnt over in the inner side, to prevent the quick passage of the heat; or, if it were made of brick, it should be lined with a mortar composed of clay and charcoal. In this box there should be a small division, of about one foot square, made of tin or very thin iron: Or it might answer to have a small box of the kind, let down in the larger one, and supported about its brim on the top of the large one. This small box, or division, should be called the *baking box* or *apartment*. B is a small pot, holding two or three gallons of water, which is connected to the cooking box, by the pipe C, which is about two inches in diameter, and two feet long. This pot is to have a cover that will fit very tight. Things being thus arranged, the meat and most vegetables are to be introduced in the cooking box A; and the bread and deserts should be, also, placed in the baking apartment. On applying fire at the pot B, it boils and the steam enters by the pipe C into the box A, and there condenses, giving up its sensible heat which acts on the meat, and passes through the tin and bakes the bread. A small orifice is to be left at the dotted end of the box for the escape of the steam. When it is designed to make soop, the articles can be readily boiled in the pot B, which should have its sides covered with charcoal mortar, to prevent any

For Doctor Ewell's Discourses

Fig 1.

Fig. 2.

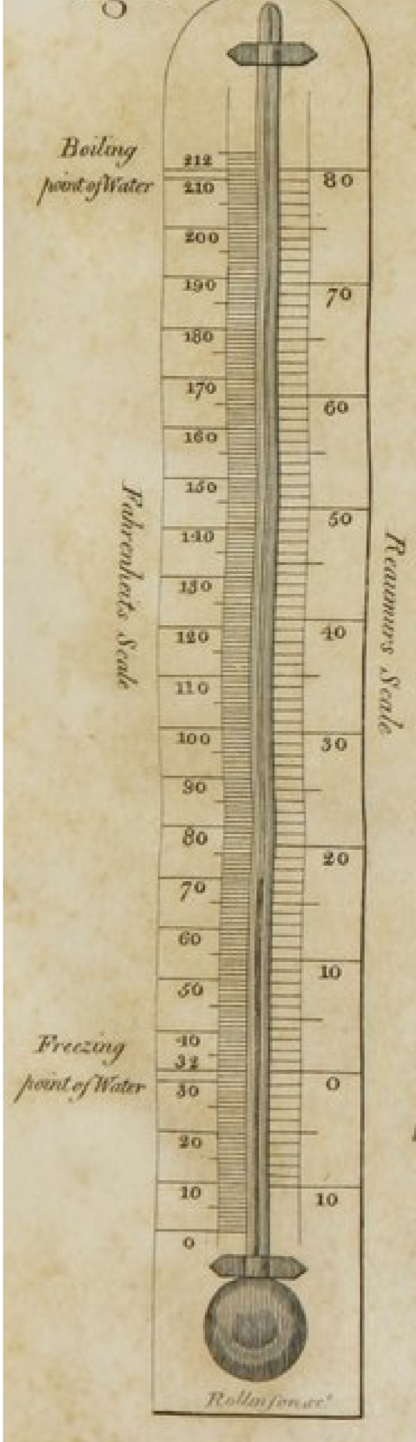
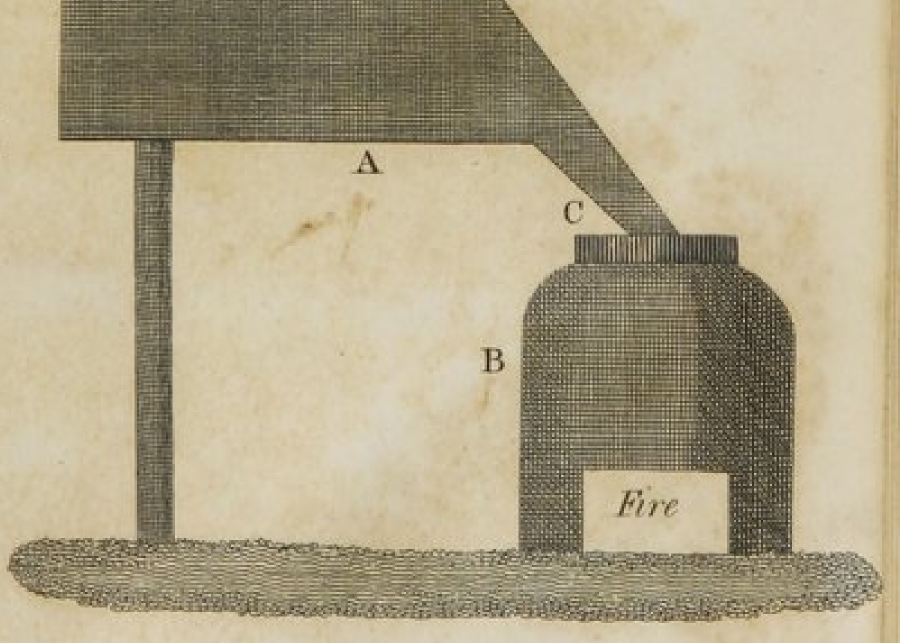


Fig 3.



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loss of heat. Before the small fire, any article can be roasted with facility, as the heat reflected will be considerable. And thus by a little attention, every article of food can be well cooked, with but a small consumption of fuel, and without injuring the health of persons by standing over large fires.

Lately the ingenious Mr. Deneal of my native village, Dumfries in Virginia, has invented a machine by which crackers are safely baked by steam. No one can doubt that any kind of bread, inclosed in thin vessels of tin or iron, tightly stopped, might be safely and well baked, if exposed to the action of steam. In some cold countries they have but one fire place in their houses; from which, pipes are carried through all the rooms for warming them. Probably it would be better if such pipes conveyed steam instead of smoke.

Travellers desirous of kindling fires of nights, generally do it by means of the flint and steel. They might kindle them more expeditiously, by providing themselves with two small vials, the one containing nitric acid (the aqua fortis of the shops) the other the spirit of turpentine. These must be mixed in small quantities, and cautiously; as, the blaze following is considerable. Sometimes vials containing a very combustible substance (phosphorus) are used. The means of preparing them, will be mentioned when considering phosphorus.

BEFORE dismissing the subject of heat, it will be proper to notice an opinion delivered by the great Dr. Black, which has since his time been published in all the systems of chemistry, as if its truth had been established.

The doctor was the first who noticed the fact, that when substances were changed from the solid to the fluid, and from the fluid to the aeriform state, generally they absorbed sensible heat, or rendered it latent. Also, that when airs or fluids were rendered solid, they gave up sensible heat. Not satisfied with this important discovery, he and all the chemists since his time have stated, that the *cause of the solidity is the loss of heat;* and that the *cause of the fluidity is the union with heat:* Hence he calls the latent heat *caloric of fluidity.* This appears to me, for several reasons, an erroneous doctrine, or rather assertion. An incidental circumstance, the absorption of heat, which must proceed from a capacity in the body *previously* acquired, is considered as the *cause* of the new properties of fluidity, &c.! What must have given the body a capacity for heat? And why may not the cause, which gave the capacity, be the cause of the fluidity? The doctor's opinion must appear erroneous from the facts, that the fluidity of bodies is not proportionate to the quantity of latent heat; and that their solidity is not proportionate to the loss of heat. A few experiments will shew these truths. If on a piece of chalk, you pour sulphuric acid, immense quantities of air will escape, although no absorption of heat or coldness will be produced. If charcoal be burnt in pure air, great quantities of heat will be set free; yet the air formed during the combustion is as fluid as the air which disappeared. Nitric acid, in a strong heat, is converted into two airs of great bulk, which contain no more latent heat than the acid did. On adding salts to water, great quantities of heat are absorbed, yet the fluidity of the whole is not increased. When water is made solid, by freezing, but little heat is extricated; yet, when it is made solid by an union with quick lime, as in slacking lime, then much heat is extricated. When we bring two airs together, the ammoniacal and the muriatic, they form a solid, yet throw out no heat. These and other similar facts, justify the conclusion that solidity and fluidity do not, as Dr. Black supposes, depend on the quantities of latent heat.

After considering this subject, I am decidedly of opinion, that the fluidity and solidity of substances, depend on the same cause which varies their capacities for heat; and this is *the exercise of the particular affinities of the body, in the circumstances existing in the different degrees of heat.*

If this be admitted, we shall no longer be surprised at the above facts I have mentioned, nor at the following; that water while freezing has its bulk increased, although it parts with heat; and that iron, bismuth and zinc, when melted, and some clays in strong heat, really contract in bulk. Nor should we be astonished at any of the effects which take place, as they all proceed from the exercise of the affinities of the bodies, in the states created, the nature of which we can only learn by experience.

HITHERTO I have spoken of heat as a distinct substance: It must now be observed, that the philosophical world has long since been divided on this subject. Some have contended that there is no such matter as heat; and that all the phenomena proceeding from what is supposed to be heat, arise from a peculiar mechanical motion. Others have maintained, that there is a particular substance, independent of other matter, which excites the sensation of hot when it enters in us, and the sensation of cold when it comes out of us. The arguments adduced in support of each doctrine have been ingenious but not conclusive. On the one hand, it has been found, that bodies weigh less, while hot than when cold; and that some contract while heated; and that others, as ice, enlarge while freezing.

This diminution of weight arises from the escape of heat from the bodies, whereby the surrounding air is prevented from pressing on them; and the other effects arise as before stated from the peculiarity of the affinities exercised in heat. The argument deemed the best in establishing the materiality of heat, is the fact, that some bodies reflect it as light. But this is not conclusive, as motion may be reflected as well as light, as is instanced in the echo of sounds. In order to determine this long agitated question, I instituted the following experiments: the first two of which were published in the Medical Repository, addressed to the celebrated chemist, Dr. Mitchill, now of the United States senate.

In two vessels of glass, tightly stopt, I accurately ascertained the weight of some water, and some neutral salts. The salts of the one were then added to the water of the other, and the vessels again stopped. As the salts dissolved, great quantities of heat were absorbed. When the absorption ended, near the fire I wiped away all the water, and found on weighing the whole again, that there was an increase of weight proportionate to the quantity of articles used. For each ounce of the mixture, there was an increase of weight of rather more than half a grain.

Two large vials, each half filled, one with water, and the other with sulphuric acid, were tightly stopped, and cautiously weighed. The water was then poured to the acid hastily, to prevent evaporation, and the vials again stopped. The sensible heat thrown out was considerable; and afterwards on weighing the whole I found the loss of weight more remarkable than the gain in the first experiment.

In the third instance, in an open mouth glass vessel, holding one quart, I introduced a six ounce vial, filled with sulphuric acid, to the cork of which a wire was attached, which was kept out of the mouth of the vessel. The bottle was then filled with water, stopped with sealing wax, and accurately weighed. This being done by means of the wire, the cork was extracted from the vial, and the sulphuric acid, gradually uniting to the water, gave out a great deal of sensible heat. When this was ended, on weighing the whole again, the loss of weight was still more remarkable.

The variations of weight in these experiments, which were made as carefully as I could make them, must have proceeded from the variations in the heat. Hence it must be admitted that heat is matter.

DISCOURSE II.

WE are now to consider the three remaining unconfinable bodies, light, electricity and galvanism.

OF LIGHT.

ALL of us know that it is through the agency of light, we see the surrounding objects; and that this light is emitted by the heavenly bodies, as well as by a few around us, particularly those which are burning, or undergoing other chemical changes.

Philosophers have advanced different theories concerning the nature of this light. By some it has been considered as a quality of matter, given by the motion of the heavenly bodies; by others as a modification of heat; but the majority, with the great Newton at their head, consider it as a substance consisting of small particles, constantly separating from luminous bodies, moving in straight lines with inconceivable velocity, and rendering objects visible by coming from them and striking the eye. That light is matter, is shewn by the facts, that its motion is progressive; it may be stopt, or its course changed; it may be condensed into a smaller, or dispersed over a larger space; and it is also subject to the laws of attraction, as is shewn by its influence in decomposing chemical compounds, and from its being attracted, when introduced in a dark room, through a small orifice, by any body which is brought near it.

In order to render what will be said on this subject intelligible, it will be necessary to explain a few terms which philosophers use.

A ray of light is an exceedingly small portion of light, which comes from a luminous body.

A beam of light is a collection of parallel rays.

A medium is the body affording a passage for the rays of light. Such bodies may be called conductors of light.

Diverging rays are those which come from a point, and separate from each other.

Converging rays are those which tend to a common point; and the *focus* is the point to which the converging rays are directed.

The light emitted from bodies passes in direct lines, unless directed from its course by other substances. Such substances as allow the light to pass through them, as glass, are called transparent bodies; they might also be called *conductors* of light. Although the light passes through such bodies, yet when it comes in an oblique direction, they divert it from a direct course, or in other words *refract it*. An idea of the refraction of light, may be formed by putting a straight stick in clear water, exposed to the sun. In consequence of the refraction of the light, the stick will appear crooked. Newton noticed, that bodies refracted light in proportion to their density; but if the medium through which it passes, be combustible, the refraction is greatest. This led him to conjecture, from the great refracting power of diamonds, that it was combustible; and, also, that water contained a combustible ingredient; which conjectures, are since proved to be correct. As our atmosphere has the power to refract light, the sun sets and rises sooner than appears to spectators. As water refracts it considerably, and as different quantities of it are suspended in the atmosphere at different times, may it not be the cause of a difference in the length of days, by variously refracting the light? Such transparent bodies, as have their surfaces convex, as the common glass lens, cause the rays of light to converge together, and such as are concave have a contrary effect.

After light passes through transparent bodies, it strikes against those which are not so, and which consequently are called opaque: they might also be termed *non-conductors* of light. On coming against these it is thrown off, or reflected, and in proportion to the reflection, is the brilliancy of the body. When the ray of light strikes the body, it is reflected, so that the angle formed on one side, called the angle of *incidence*, is equal to the angle formed on the other side, called the angle of *reflection*.

Opaque bodies reflect light in all directions. The light reflected from the objects we see, penetrates the transparent humors of our eyes, from the convexity of which, the rays of light are converged together. They then strike against the nerve of the eyes, and excite motions, which when communicated to the brain, constitute our ideas of vision. All our ideas of color proceed from the motions thus excited in the nerves of our eyes. Therefore one object differeth in appearance from another, inasmuch only, as there is a difference in the action excited by the light reflected from them. Hence if we suddenly strike the eye, we have the idea of a flash of light, in consequence of the pressure exciting an action in the nerve of the eye, like that which light would do.

By what means is it that light excites in us ideas of the different color of objects? In order to solve this question, Newton supposed that light was a compound body, each ray of which was formed by the union of seven rays of a different kind. This supposition, now almost universally received as correct doctrine, is grounded on the following experiment: on taking an irregular shaped glass, called a *prism*, and applying it before a small hole, where a ray of light enters in a dark room, the ray will seem divided into seven different parts, the lowest being red, above this orange, then yellow, green, blue, indigo, and lastly violet. He moreover found, that these seven different parts of light, when united together, formed the original or white ray. Upon this experiment, he stated, that the color of bodies depended on the absorption of some rays and reflection of others. For example, that the redness of a body is in consequence of the absorption of all the rays excepting the red; that yellowness is in consequence of the absorption of all the rays but the yellow, and the same of the rest of the colors. He also added, that whiteness arises from the reflection of all the rays; and that blackness arises from the absorption of all of them.

It appears to me, that the experiment on which this theory of the composition of light is founded, is by no means conclusive. That light on passing through an irregular shaped glass, should be variously affected, and consequently excite corresponding motions in our eyes ; that one part of the glass should so act on the light, as to make it excite the idea of red, that another part of the glass should cause the light to excite the idea of green, and so on of the rest of its parts, does not appear surprising. Nor is it astonishing, that an union of these rays, so acted on, should be followed by the restoration of the original power of the ray. But, even, if the doctrine of the composition of light were true, it could not account for all the color of bodies. To suppose that blackness is in consequence of the absorption of all the light, must be absurd ; since, it is only by the reflection of light, that we are enabled to see black bodies, and since bodies, which are transparent, and of course allow the light to pass through them, are very far from being black. That whiteness does not proceed from the reflection of all the light, is shown by the circumstance, that the whiteness of bodies is not proportionate to their reflection of light. Hence, mercury, polished iron, and other metals, reflect more light than the whitest paper.

Since the above theory of the composition of light was advanced, philosophers thinking it, I suppose, too simple, have added to it considerably. The seven rays, which I have named, they call colorific, to distinguish them from two other kinds they have been pleased to name, the one *calorific*, because exciting heat ; the other *de-oxidizing*, because capable of separating oxigen from some bodies. The facts, that certain modifications of light, expedite the extrication of heat, and oxigen, do not justify these theories ; and, consequently, I shall here leave them, under the belief that they are too complex to be true.

As then it has not been proved that light is a compound, and as it is contrary to the uniform simplicity of nature, that it should have been made so, I conclude that it is like heat, a simple elementary substance. Of course, the various colors of objects, cannot proceed from the absorption of some rays and extrication of others Our ideas of the color of bodies, appear to depend solely *on the peculiar modification or motion of light, given by the reflecting surfaces.* The reflecting surfaces, probably receive their respective powers, in consequence of peculiarities in their mechanism, or organization. For example, our idea of the redness of a brick before us, is in consequence of a peculiarity in the mechanism of the brick, enabling it so to act on light, as to cause the light escaping, to excite in our eyes the motion constituting the idea of redness : and the same of all other colors. Now, as bodies vary more or less in their organization or mechanism or construction, it follows,that they should give the various qualities to light, enabling it to excite the great variety of ideas of color. If this be correct, in order to give one body the color of another, we have only to give it a similar reflecting surface. The means of doing this, which come under the heads of dying and painting, will be mentioned elsewhere. It may, however, be here remarked, that the motion given to bodies called green, experience has shown to be least pernicious to the eyes ; therefore, a preference should always be given to green colors.

The above theory is supported by the following facts : by various mixtures, acting chemically, the light emitted during combustion, can be made to assume particular colors, or in other words, excite particular actions in the eye, as red, green, blue, &c. The light coming through a round glass vessel, containing one colored fluid, may be made to excite different ideas of color, by varying the position of the vessel. In the clouds we also sometimes see the most beautiful modifications of light, from a scarlet to a sky blue.

As light, like heat, is emitted during the chemical action of bodies on each other, it follows, that like heat, it had been combined with them, forming one of their solid component parts. When so united it should be called *latent light*. The capacity of bodies to unite with it, varies considerably; some containing much more of it than others. Fluid substances appear to contain more of it, as well as heat, than solids; however, the fluidity we should not attribute either to the light or heat: yet we find that when bodies unite with an unusual quantity of light, their capacity for heat is diminished. Every one knows, that the light of the sun causes an increase of sensible heat. Dr. Franklin long since noticed, that black bodies, exposed to light, emitted more heat than white ones. Hence the advantage of wearing white clothes in summer. It has already been observed, that most intense heats have been generated, by bringing the rays of light together, by means of a lens. There can be but little doubt, but that the heat emitted in such cases, is in consequence of the union of light with the bodies, thereby depriving them of their capacity for heat. Hence we find, that the absorption of light is proportionate to its intensity; and the extrication of heat is proportionate to this absorption. It appears to me highly probable, that many of the sudden variations of the temperature of different spots, arise from variations in the capacities of substances to absorb light, and consequently give out heat. May not these capacities be most materially affected, by variations in the quantities of water, electric fluid, growth of plants, &c.?

The means of extricating light from bodies may be divided into such as are mechanical, and such as are chemical. The mechanical means are very few. Simple pressure, in some instances, causes the extrication of light; as is the case, when two hard stones are struck against each other in the dark, whereby the air is compressed, and the light squeezed out, as appears by the flash following instantly. The electric fluid also, when passing through air, sets light at liberty, by taking its place. This is the reason why flashes of light follow the quick passages of electricity.

But the purest light is emitted during the combustion of bodies. It is, like heat, yielded by the air consumed, as well as the body burnt. When the combustion is perfect, by the proper supply of fresh air, the light is in largest quantities. Hence the superiority of Argand's lamp, which by admitting fresh air directly to the burning oil, so favors the combustion, that the oil is not evaporated, or lost in the form of lampblack; but is entirely consumed. A mixture of oil and phosphorus in a vial when uncorked of nights, will give out sufficient light for distinguishing the figures of a watch. The method of preparing this will be given under the head of phosphorus.

The above facts clearly shew, that light combines with other substances, as well as the following. Light is emitted in the night, from several substances which had been exposed to it during the day. Such are called *Solar phosphori*, or substances which shine in the dark, without giving out heat; of which there are great varieties. Putrid fish, flesh, and rotten wood, do it sometimes in a very remarkable degree; lightning bugs, the eyes of cats, owls and several other animals, appear to do it under some circumstances. Snow and ice seem to absorb light all the day, and emit it at night, so as to prevent total darkness. Chemists have made a number of compounds, possessing this property in an eminent degree. Of this kind, are Baldwin's phosphorus or nitrate of lime; Bolognian phosphorus, or sulphurate of Barytes; and several other bodies, useless to name or describe. Many other bodies emit light when exposed to a high heat, such as diamonds, metals, magnesia, &c.

The effects produced by light as a chemical agent are now to be mentioned. Mr. Lavoisier observes, that "organization, sensation, spontaneous motion, and life, exist only at the surface of the earth, and in places exposed to light. We might affirm, that the flame of Prometheus' torch, was the expression of a philosophical truth, which did not escape the ancients. Without light nature was lifeless, inanimate and dead. A benevolent God, by producing light, has spread organization, sensation, and thought, over the surface of the earth."

The direct influence of light on animals is very considerable. In general they become unhealthy, thin, and weak, when secluded from light: when long confined in a dungeon, a man's complexion becomes languid and dropsical. Insects living under ground, and mice and other animals confined in holes, become of a white color. The bellies of fish and birds are of a light complexion; no doubt, in consequence of their want of light. On the other hand, it is well known, that animals exposed to light, have their color materially altered; and it no doubt produces other changes: it forms one of their constituent parts, as proved by its emission during putrefaction.

The effects of light on vegetables are not less remarkable. Every one knows, that several flowers follow the sun in his course, attend him at his evening retreat, and by the same law, appear before him at his rising. The leaves of many plants change their position at different periods of the day; and those growing on the inner side of windows, seem solicitous of growing towards the outside, in consequence of light. It has long since been noticed, that plants growing in dark places are pale and without color; and gardeners daily avail themselves of this fact, to furnish our tables with white and tender vegetables. After the plants grow to a certain height, they compress the leaves by tying them together, or by covering them with earth, so as to deprive them of light, when they become white soon after. It would probably be much better to cover them with tight wooden boxes. By such means, they have white celery, lettuce, cabbages, endive, &c. Red and other colored roses and pinks have also been made white, by preventing the contact of light; and all the plants of the kitchen gardens might be rendered so, by the same means. Grass growing under stones and other dark places, is always white, soft, aqueous, and of an insipid taste. The roots of plants are also less colored, than the parts exposed to the sun. Some of them acquire a deleterious quality when suffered to grow exposed to light: as, potatoes, celery, &c. Some plants emit vital air when exposed *to light*, and the more others are exposed to it, the greater is their color, taste and odour. It also contributes very much to the ripening of fruit and seeds. It appears to be the cause why, under the scorching sun, near the equator, vegetables are more odoriferous, of a stronger taste, and more abounding with resinous matter. Hence the greater number of perfumes and acrid spices, which are procured from within the tropics.

Lastly, light produces great effects on inanimate substances. It causes the decomposition of several chemical compounds, and the separation of vital or pure air, in some instances. These compounds will be more properly mentioned in another part. It is well known, that the color of many bodies are destroyed by light. Hence wax, linen and cotton, are frequently exposed by housewives to light, to be bleached or rendered white. Several considerations led me to suppose it instrumental in favoring the compound, which causes yellow fever; these will be mentioned in the next discourse, while treating of contagion. In all such cases, no doubt, sensible light acts like sensible heat, in creating the particular circumstances in which combinations of other matter take place by the exercise of their affinities.

ELECTRIC FLUID.

THE various effects proceeding from electricity or lightning, as it is commonly called, are supposed to arise from a fluid which can only be distinguished by such effects. This fluid, like heat, is dispersed over all nature, and has a strong tendency to establish an equilibrium, or be equally distributed over every body. Notwithstanding this tendency, it is frequently accumulated in considerable quantities, by the operations of nature and art, as all of us know.

The same doctrine that was delivered concerning heat and light, should be extended to electricity. We, therefore, must observe, that some bodies have a *capacity* to unite with it, and render it *latent*, from which state it may be converted into *sensible* electricity, by mechanical and chemical means. When converted in large quantities in the sensible state, it makes its escape so rapidly, as to occasion sometimes the loudest noise, or claps which every one has heard.

It is chiefly by mechanical means, or friction, that electricity is commonly accumulated. By rubbing some substances, it is collected on their surfaces in considerable quantities: And they are called electric bodies. Such substances have, no doubt, a great capacity for electricity; and, in consequence of containing large quantities, readily give a part of it up when rubbed. These are also remarkable for resisting the passage of the fluid; and are consequently called *non-conductors* of electricity, to distinguish them from those favoring its escape, which are called good conductors. The most remarkable of the *non-conductors* of electricity, are, amber, glass, sulphur, sealing-wax, silk, feathers, hair and wool. By rubbing any of these briskly on a dry woolen cloth, at night, the collection of the fluid may be readily noticed, by the sparkles which take place. The *conductors* of electricity most remarkable, are the metals. Of these silver, copper, and iron, are the best. A moist atmosphere, also, conducts it quickly.

In order to collect the electric fluid, an electrical machine is used, which, being so common, it will be unnecessary to describe. The principles on which it is formed are very simple. By the turning of a round non-conductor, such as a glass cylinder, against silk, the fluid is collected. To prevent its passage to the earth, the machine is insulated, or separated from the surrounding bodies, by being supported on non-conductors, as glass or sealing-wax. It is necessary, however, that the machine be connected to the earth, by a conductor of the fluid, as iron wire, for the purpose of conveying it from the earth to the apparatus. When this machine is made on a large scale, immense quantities of the fluid can be collected, in dry weather, and retained some time in glass vessels made for the purpose. From these it is applied to bodies, where it produces great effects. It melts the hardest metals, and decomposes a variety of compounds. In such cases it no doubt operates like light and heat, by creating certain circumstances in which the affinities of particles of matter are exercised. In its passage through the air, it is characterised by the emission of light and heat. These are, in all probability, emitted in consequence of the fluid depriving the air of its capacity for latent light and heat.

It was the great and benevolent Doctor Franklin, of this country, who first discovered that the lightning of the sky is the same as the fluid collected by the above machine from the earth. When it is collected in the clouds, from its tendency to establish an equilibrium, it rapidly escapes to the earth, there producing the flash of light and thunder.--- The propriety of having conductors of the fluid attached to houses, to convey it from the clouds, must readily appear. Iron rods, tipped with brass or silver at the points, are generally used.

It is well known that the electric fluid, when in considerable quantities, destroys most animals; yet, some of them, the torpedo, for example, have the power of collecting it in great quantities, which they emit at pleasure for the destruction of their enemies and prey.

If the doctrine I have delivered concerning electricity be correct; if it unite to bodies and become latent, as heat and light, chemical changes in substances would naturally produce alterations in the capacities of bodies for it, as well as in their capacities for heat and light. Accordingly this appears to be the case in some instances, although generally, the escape of the fluid cannot be detected, as it flies off gradually. Lately, it has been found, to the great astonishment of European chemists, that sulphur (which is electric, or contains a great quantity of electricity in a latent state) when melted with copper or iron in a Florence flask, from which all air is excluded, unites to the copper, and appears to burn. About the bottom of the mixture, a sparkle appears which expands over the whole, giving it the appearance of blazing. This sparkling and blaze, no doubt, arise from the escape of the latent electricity of the sulphur, which is set at liberty on its chemical union with the metal. The sparkling of the water of the sea, of red hot metals, and of some other bodies, very probably depends solely on the escape of this fluid. It also appears to me exceedingly probable, that the frequent and great collections of *sensible* electricity in the clouds, noticed during storms, arise from chemical changes in the air, whereby the capacity of the air to retain the latent substance is lost. An union of the air with water, and with other substances, may no doubt produce the changes causing alterations in the capacity of the atmosphere for the latent electricity.

The progress then of the electricity, causing thunder during storms, seems briefly this: In consequence of the great moisture of the atmosphere near the earth, its capacity for uniting to the electric fluid is increased. The air, impregnated with moisture and electricity, ascends in the form of clouds. Some chemical changes occur in this air, in consequence of which, its capacity for heat is increased, and it therefore absorbs the heat of the vapor. The vapor, losing its heat, is converted into water, which falls in the form of rain, or hail; in consequence of the loss of moisture, the capacity of the air for electricity is lost: it is, therefore, converted into sensible electricity, which flies off to be equally distributed, and in its flight deprives the air of its capacity for light, and thereby causes the flash.

GALVANISM.

GALVANISM, resembling in a few of its properties the electric fluid, is one lately and accidentally discovered by an Italian, and which is generally termed galvanism, or animal electricity. In nature, it exists only in a *latent* state; and it can only be made *sensible*, by chemical action, whereby the capacities of bodies for it are lost.

Galvanism may be collected or made sensible by a very simple apparatus. For this purpose, thin plates of zinc and silver, or zinc and copper, are to be placed alternately, one above the other; between each of which, thin paste board, or any other porous substance, moistened with an acid or any saline solution is to be put. When this is done, the saline solution acts on the metals, and *the galvanism is proportionably generated*. A pile of this kind, consisting of 30, 40 or more pieces of each metal, excites the galvanic fluid so strongly, that when the top and bottom pieces are at the same time touched by the fingers moistened, a sensation is communicated similar to that given by electricity, and a luminous spark may also be produced by it. The operation of this fluid, in restoring drowned persons to life; in exciting action in dead animals, and in effecting the decomposition of some compounds, is very remarkable. When a metallic wire from the plate at the top of the column, and another from that at the bottom, are introduced in a vessel containing water, ardent spirit, volatile alkali, or some other compounds, a decomposition immediately commences, and continues to go on as long as the apparatus excites the galvanism. Such chemical changes are wrought upon the same principles that those are which take place in heat, light, and electricity.

It is highly probable that the agent concerned in the production of these phenomena, is the electric fluid somewhat changed or modified. This appears from the feelings it excites, from the spark it emits, and from its passage being favored by the *conductors* and resisted by the *non-conductors* of electricity. But there are sufficient reasons to form a distinction between the two fluids.

A number of experiments more curious than useful have been made with galvanism. Such as wish to know more on the subject, can consult the treatise by Volta.

DISCOURSE III.

WE now are to consider the qualities of those bodies which are called *confinable*, as they can be confined in our vessels. It is in the consideration of these, that we learn the particular affinities or tendencies of substances to unite with others. The elements, heat, light, electricity and galvanism, are chiefly distinguished by their creating particular states, in which particular affinities of the confinable bodies are exercised. These, it must be remembered, are not the only agents which create states or conditions for the exercise of affinities. Any substance present, as air or water, for example, may be chiefly instrumental, or have great influence in the formation of states or conditions, for the exercise of the affinities between any two bodies. An idea of this may be formed by adding sulphuric acid to one iron vessel, and water to another: no action ensues. But if the sulphuric acid be mixed with the water, then particular affinities are exercised, and consequently changes take place. This will, in other instances, be noticed; so that some confinable bodies will exert no action on each other, unless a third one, of a particular kind be present. Hitherto, chemists have stated, that these third substances act by virtue of a *disposing affinity*. This appears exceedingly erroneous;

for it seems impossible to conceive of such an affinity. The substances stated to act by this disposing affinity, act on the same principles that heat, and the other unconfinable elements do, *viz.* by creating *states or conditions*, for the exercise of the affinities of bodies. On the influence of such substances is founded the distinction between decomposition in the *dry* and in the *humid* way. Chemists, as before observed, have only to notice what substance creates the state in which other substances exercise affinities.

The confinable bodies we shall first consider are, *the elastic fluids*, or *aeriform substances*. By these bodies, is meant those which are commonly called *airs*, and very unnecessarily, by chemists, *gases*. An air, or a gas, may be defined, a compressible and invisible fluid. Our atmosphere, or the invisible fluid which we breathe, and which surrounds the earth, is an example of a substance existing in the aeriform state.

While considering heat, it was remarked that most solid bodies, when highly heated, were in consequence of the affinities exercised in that state, changed from solids to fluids, and then to airs, in which state they *generally* absorbed or united to sensible heat. The term vapor, is applied to such of them as are returned to the state of fluids in a low heat, as water; and the term air, is more particularly applied when the bodies are not restored to fluids in any low heat we know. The distinction then between vapor and air is only relative, depending on the degree of heat in which this condensation takes place.

By an air, we must therefore understand, a solid body changed into that state, in consequence of the exercise of those affinities, peculiar to it in a certain degree of heat. The solid body so changed, is called the base of the air;

and the airs are named according to their bases. The properties of the airs are found to vary with their bases, and are, no doubt, much influenced by the sensible heat and light to which they unite, and render latent in some instances in great quantities. We have, for example, one air which will support life and combustion, another will not support either; one is inflammable or will burn, another is soluble in water, &c. so that the qualities of all airs vary with their bases, or with the solids which form them.

In order to examine the qualities of the various airs, an apparatus is necessary, which is designated by the term *pneumatic apparatus.* It is proper to give some idea of it in this place, as it was chiefly instrumental in enabling chemists to treasure up their important information concerning the airs. A representation of it is given in plate II, fig. 1. A is a trough or tub, generally about three feet long, eighteen inches wide, and as many long. Two or three inches below its brim a horizontal shelf is fastened, about one third the width of the trough. Through this shelf are several holes wider beneath than above, of a funnel like shape. This trough or tub is filled with water, sufficient to cover the shelf about an inch. The use of this shelf is to support vessels, such as, tumblers, jars, and bell-glasses, in which the airs are confined. They are first to be filled with water, and with their open mouths downwards, are to be slided over one of the holes in the shelf, as the glass vessel is represented on the tub in the above plate. When the air is thus conveyed to its mouth, by means of a tube connected to another vessel, as that represented at the side of the tub, it immediately rises in the vessel, and the water proportionably sinks. Figure 2, of the above plate is a *retort*, which is very generally used in the preparation of different airs. It is made of glass, iron or clay, to suit the operator.

It may be well, previous to experimenting, to acquire the habit of managing airs, in the *pneumatic* tub. This may be done by conveying atmospheric air from one vessel to another. Take, for example, a large tumbler, (which is a very good substitute for a bell-glass) fill it with water, and with its mouth downwards slide it over one of the orifices on the shelf of the tub. Take another glass, in the condition that is commonly called empty, and, on putting this in the water with its mouth downwards, no water will enter in consequence of the air that is in it. On introducing this vessel underneath the one filled with water, and turning it towards aside, it will be found, that the air will ascend in the upper vessel. By these means, carefully attended to, airs can be readily conveyed from one vessel to another. When an air is to be prepared which is soluble in water, it is then necessary to use mercury instead of water. In this case, the pneumatic trough is made small, and of marble.

In ascertaining the qualities of all airs it is necessary, that the temperature should be uniform; as airs are expanded differently in different degrees of heat, as before remarked.

Of the aeriform bodies, none claim more our attention than the atmospheric air around us. It was hinted, while considering heat, that it was a compound body. This will clearly appear from the following:

Take a Florence flask in the state called empty, introduce in it a burning taper, and then stop the mouth. The taper will gradually burn more dimly until it is extinguished. Then open the flask in water with its mouth downwards, and it will be found that the water will rise in it to supply the place of the air, which disappeared during the combustion. The air remaining in the vessel will neither support animal life, or combustion; for if any animal be introduced in it, death quickly follows; or if any burning body be introduced, it is instantly extinguished.

If a vessel containing 100 parts of atmospheric air, confined over mercury be taken, and a quantity of the filings of iron or of lead made red hot, in a close vessel, be conveyed in the above air, they will then burn, and this burning may be increased by the focus of a lens. After the combustion ceases, it will be found, that about twenty-four parts of the air have disappeared, so that but 76 parts remain in the vessel. This air, like the above, will be found incapable of supporting life or combustion, and the metal will have lost its brilliancy, and will appear *rusty*. As the base of this air is found in large quantities in nitre, it is called nitrogen air.

If the metal so burnt be then introduced in a small glass tube, connected to the pneumatic tub, and made red hot, it will part with the air to which it had united, and re-assume its metallic brilliancy. If the experiments have been performed with the greatest accuracy and success, precisely 24 parts of air will come over.

The twenty-four parts of air so obtained, possess properties very different from the 76 parts remaining in the first vessel. This air will support animal life, and a burning body introduced in it will burn with great brilliancy, and as much as it would in the original 100 parts of atmospheric air. Some bodies, as sulphur, when burnt in this air, become acid or sour, and in consequence it is called *oxigen* air; the word oxigen denoting the origin of all acidity.

Now, if the above two airs be re-combined, they will form again 100 parts of atmospheric air. Therefore, our atmospheric air is a compound, formed by the union of two airs, possessed of different properties, which may be separated into 76 parts of nitrogen air and 24 of oxigen air, and which may be united again together.

Before entering further into the consideration of our atmosphere, in order that its properties may be best understood, it will be proper to give some account of the two airs of which it is composed; and first, of

OXIGEN AIR.

THIS is the only air which supports life, as animals soon expire whenever it is withheld from them. While breathing, this air is applied to the lungs, where it imparts to the blood heat and new qualities. Its presence seems also necessary for generation, as will appear from a paper of mine that will be found in the 38th number of the Medical Repository. In consequence of its supporting life it has been called vital air; but the term oxigen is better, as it expresses one of its properties (that of causing acidity) and answers other purposes. Persons should make themselves familiar with this word, as it, and its modifications, are unavoidably and much used. This air has neither taste, odour, or the properties of acids. Its weight is, to atmospheric air, as 1103 to 1000. The base of this air is called oxigen, which is considered as an elementary body. This base has never been obtained free from combination, and its existence is only inferred from effects it uniformly produces. Oxigen exists in the greatest purity in the purest oxigen air: however, in this state, it contains more latent heat and light than any other air. It has a strong tendency to unite with many other bodies, particularly in a high temperature. Generally when it does unite to them, it throws out great quantities of heat and light, thereby producing the flame noticed during combustion. Indeed it is the only substance which, when combining with other bodies, allows the disengagement of heat and light. Hence it is the only substance which supports combustion. By inflammable, or combustible bodies, we must therefore understand such as may be *oxided*, or as are *oxidable*, or capable of uniting to oxigen. When such substances are heated, they attract the oxigen, and form with it a compound which not possessing the capacity for the heat and light that the air did, allow them to be emitted in the sensible state. This union, however, is not *always* attended by the emission of considerable quantities of heat and light; and even in some instances none that is perceptible is extricated: the product formed, has the capacity, in such cases, to retain the heat and light. We have an instance in nitre or saltpetre, which contains great quantities of oxigen, that retains its heat and light. Hence, when nitre is mixed with coal, as in gunpowder, and fire is applied, great heat and light are extricated, because the oxigen unites to the coal and forms a compound which has not the capacity to retain them. When combustible bodies are heated and introduced in pure air, they unite to oxigen with great rapidity, causing a dazzling emission of heat and light. Hence the oxidation, or combustion of a body, is proportionate to the quantity of oxigen present. Hence the reason why a given quantity of air will last only for a certain time.— And hence the increase of weight which a body gains in burning (allowing for the loss of heat and light) always precisely corresponds to the loss of air. The theory of combustion may be better understood by referring to what was said on the subject while considering heat.

When oxigen unites to different bodies, compounds, possessed of very different properties are produced, as airs, fluids and solids. Most of the vegetable bodies unite to it and escape in the form of airs. The metallic bodies unite to it, and form what are commonly termed *rusts*, but which chemists more properly call *oxids*. Other bodies, as sulphur and phosphorus, unite to it and form a class of compounds, numerous and important, known by the term *acids*, and generally possessed of the following remarkable properties:

1. They have a strong tendency to unite with water.

2. They produce the sensation of *sourness* when applied to the tongue.

3. They change most of the blue vegetable colors to red, by which property they may be readily distinguished.

4. They unite to the alkalies, metallic oxids, and several earths, forming compounds called *neutral salts*, as nitre, common salt, or copperas.

Oxigen air is generally procured for the purpose of experimenting, by one of the following methods:

1. Take a quantity of fresh gathered leaves of plants, put them into an inverted bell-glass filled with pump water, and expose the whole to the action of the light of the sun. The air will then rise up tolerably pure in the glass, as will appear by the rapidity with which any thing will burn in it.

2. Common nitre or saltpetre contains, as before observed, a great deal of oxigen; and if it be heated in a glass retort, the air will come over pretty pure.

3. Black oxid of manganese, sold and called by potters *manganese*, or the red oxid of mercury of lead, or of any of the metals, if heated red hot in a retort, will give over great quantities of oxigen air; and they will be restored to their metallic state. In such cases, the first air that comes over should be thrown away, as it contains a great deal of the

air of the vessel; and it should be shaken over lime water to free it of fixed air.

The importance of oxigen in the mineral, vegetable and animal kingdoms, will be better understood when we consider the compounds into which it enters.

NITROGEN AIR.

NITROGEN is the name of an elementary substance, which, like oxigen, has never been obtained free from combination. It appears to exist in great purity in nitrogen air. This air was formerly termed azotic air, in consequence of its killing animals, (which other airs do also) but Chaptal more properly called it nitrogen, as it exists in great quantities in nitre, as before observed. This air extinguishes burning bodies, and destroys animals. Its weight is, to atmospheric air, as 925 to 1000. It has no sensible taste, nor is it absorbable by water. It is not characterized by other remarkable properties.

The methods of obtaining this air pure are very simple. It may be had by burning any body in confined atmospheric air, whereby the oxigen becomes separated. Or a mixture of potash and sulphur wetted into a paste, and put in confined atmospheric air, over water, will absorb the oxigen in a day or two. A more expeditious method is, to inclose lean beef in a retort with diluted nitric acid, and on applying the heat of a candle, the air will come over in great quantities.

Nitrogen is one of the most important elementary bodies. Although it be not like oxigen, useful in respiration, yet it forms the chief part of animal bodies. It enters into combination with a variety of bodies, forming useful compounds in the animal, vegetable and mineral kingdoms, which will be hereafter named. At present we shall only consider its combinations with oxigen, and we will return to

ATMOSPHERIC AIR.

OUR atmosphere is not only compounded of oxigen and nitrogen, but it contains a variety of other substances which it holds, as it were in solution. All the bodies around us, which are susceptible of evaporation, are from time to time united to it ; so that its impurities are sometimes exceedingly great. It occasionally not only contains substances destructive to animals immediately, but such as cause their death by taking the place of vital air. All over the world it is found blended with water and fixed air. Its attraction for water is so strong that it can be had dry only, by confining it over the caustic alkalies. Rather more than one hundredth part of it, is universally found to be fixed air ; and in some parts the quantity is greater. It may be perfectly freed of this air by agitating it over lime water, and the diminution of its bulk will indicate the quantity that had been present.

In order to ascertain the proportion of oxigen air in our atmosphere, an instrument is necessary, which is called an *eudiometer*. This is a simple glass tube, closed at one end, with a regular cavity, and divided into 100 equal parts. In this tube, filled with water and its mouth downwards, 100 parts of the air to be examined are to be introduced. The method then to ascertain the quantity of oxigen, is differently stated by different authors, and none of them are *perfectly* correct. However, the best way is to introduce a bit of phosphorus at the end of a wire up in the air, and apply fire at the side, when the phosphorus quickly burns, unites to the oxigen, and the water in the eudiometer rises in proportion to the loss of oxigen.

Next to this method appears to be the introduction of wetted potash and sulphur, which slowly absorb the oxigen. Probably the average quantity of oxigen which will be by these means detected in atmospheric air, is about 24 parts in the hundred. Some, however, state it to be but 22, and others 27.

Our atmosphere frequently destroys animals by containing large quantities of substances, which, when introduced in the lungs remain inactive and serve mechanically to prevent the contact of vital air, as water does, when people are drowned. It may always be ascertained, whether the air of any place be so blended, by introducing a burning candle, attached to a stick If the candle, or any other combustible matter be extinguished when introduced in it, or if it burn very dimly, such airs will certainly prove destructive to animals. This, therefore, affords a safe criterion, by which people may judge of the state of airs, in all caves, wells, rooms, &c. before their entrance. The extinguishment of the candle in such cases, is in consequence of the want of oxigen.

Now, if it be desired to ascertain what particular air occupies the place of oxigen air, it can be readily done, by introducing a bottle filled with water, and emptying it in the place, at which time the air fills the bottle, which should be corked immediately. If on applying a candle to the mouth of the bottle the air does not blaze, it certainly is not inflammable air. The air is then to be put over lime water, and if it be absorbed by the lime so as to form chalk, the air is certainly fixed air. If it be not absorbed by the lime, it may safely be concluded that it is nitrogen air, formed in consequence of some body having absorbed the oxigen from atmospheric air. In all these cases the airs can be perfectly corrected, by free dilution with, or circulation of atmospheric air. When fixed air is the cause of the impurity, its removal may be expedited by throwing in lime or lime water. It is this air which so generally is found in wells, breweries, &c.

Besides the impurities of our atmosphere from the above causes, it is frequently rendered injurious to animals, in consequence of containing substances which the chemists, cannot detect. These are the great variety of contagions, or infections, which produce small pox, measles, malignant or yellow fever, &c. The nature of these substances is unknown, and their existence is only inferred from effects they produce on living animals, and particularly on men. The chemists have been unable to do any thing with any of them, except that causing yellow or malignant fever. This is designated by the term *miasma*. It is a compound formed during the putrefaction of animal and vegetable matter, in the circumstances often existing in warm countries, and particularly in cities. Immense quantities of it have lately been generated in the United States; and New-York, Philadelphia, Baltimore, Charleston, Savannah, and New Orleans, will long bear traces of its ravages, as well as several European cities; amongst which, Genoa, Leghorn, and Cadiz, have most suffered. When this miasma is in its strongest state, it excites the plague; as we frequently find in Egypt, and throughout Asia and Africa. In a less active state, it excites the jail, hospital, and ship fevers; also the malignant or yellow fever, which is observed in the East and West Indies, in the United States, and southern parts of Europe. In a still less active state, it produces the fevers all over the world, called billious or remittent, and intermittent fevers.

The means of correcting the airs containing miasma, have long occupied the consideration of chemists. It is only of late that successful methods of effecting this have been discovered. Experience has uniformly taught, that it is folly to expect any good from large fires, from flashing gunpowder, from smelling camphor, tobacco, or any of the volatile vegetable substances; even strong common vinegar, so universally used, is found of little or no service.

Dr. Smith of London, discovered that the fumes of the nitric acid had a happy effect in purifying infectious air, particularly that arising during the putrefaction of animal matter. To dis-infect rooms and ships, the Doctor advises that a quantity of nitre be warmed in a glass vessel, and an equal quantity of sulphuric acid be poured on it. When this is done, the fumes of nitric acid will ascend in the form of red clouds, which quickly spreading around will destroy the contagion very effectually. The quantity of the articles used in this process, should be regulated by the quantity of air to be purified, allowing two ounces of the mixture to a common room. By using these fumes in England, the jail, hospital, and ship fevers, have been at once arrested in their progress. The same happy effects followed its use in the north of Europe, and also in the East Indies, in some remarkable instances. The advantages resulting from this discovery were so great, that the British parliament, in conformity to their liberal custom of rewarding useful men, gave a considerable sum of money to Dr. Smith.

Notwithstanding the great value of the fumes of nitric acid in correcting contagious airs, Guyton de Morveau, and some other French chemists, have ascertained that the fumes of the muriatic acid are superior. These have been found to be particularly successful in destroying the miasma causing the yellow fever, and other epidemical diseases of hot countries. In order to diffuse these fumes in the air, to one ounce of dried common salt should be added the same quantity of sulphuric acid diluted with half as much water. When this is done, very pungent fumes will ascend (which are the muriatic acid, gas or air) and spread around in sufficient quantities to purify the air of a large room. Another preparation, however, of this acid, is found still better. About three ounces of salt, half an ounce of the powdered manganese used by potters, two ounces of the sulphuric acid, and one of water, should be mixed together in a warmed glass vessel. This being done, a most volatile air (called the oxi muriatic gas) will ascend and completely destroy the contagion, or miasma of a large room. Morveau gives a decided preference to the use of this article over all others in purifying infected places. By it, he completely corrected the air of a church in Dijon in France, which was so corrupted from putrefaction, that no one could enter it with safety. With the happiest success, it has lately been used in destroying the miasma, which operated so fatally in parts of Italy, France, and Spain.

It should be observed, that more caution is necessary in the use of the fumes of muriatic acid than in those of the nitric, which can be inhaled with safety by any one. My friend and fellow graduate, Dr. Hartshorne of Alexandria, made some experiments with the fumes of the muriatic acid; by which it appeared they were very fatal to the life of mice and puppies. Although they have been respired by men without injury, yet it would be well to be cautious in not remaining too long in the room when they are escaping.

These fumes, no doubt, act by uniting to the miasma thereby rendering it neutral. The expence of preparing them is so trifling, that they should be used in all suspected places. By using them in ships, and about their contents, really more good will be done in one hour, than can be produced by the longest quarantine they are made to perform. The benevolent President, has called the attention of Congress to this subject in a late message, with a view to remove the grievances arising from quarantine laws. Surely the merchants should strive to hasten the abolition of these restraints on commerce, by introducing the perfectly safe, and expeditious method of fumigating their ships and goods as above proposed.

Some persons have attributed great virtues to slacked lime; but with what propriety remains to be determined. Probably it only acts by resisting putrefaction. However there is a doctrine which has for its support the opinion of Dr. S. L. Mitchill, that the lime and also the alkalies operate by absorbing the miasma, which the Doctor calls the *sceptic acid*. At all events in the cities, where the privies are very offensive, the lime thrown in, has a happy effect in correcting the smell of the air. Perhaps in such cases it would be better and less expensive to use the fumes of the acids. The lime might be better employed, if sprinkled over the narrow and dirty streets in the unhealthy parts of the cities, as it could certainly correct putrefaction.

From a variety of facts, which have been accurately attended to, it is well ascertained, that the activity of miasma is lessened, nay, completely destroyed, by a free circulation of, or dilution with atmospheric air. Hence, during the most fatal plagues which have prevailed in Aleppo, Alexandria, and Grand Cairo, in Egypt, the wealthy people safely retire to the upper stories of their houses; where the miasma cannot ascend from the streets without great dilution with air. It would be advantageous if such as are obliged to remain in our cities, during the epidemical fevers, would reside in the upper parts of the highest houses. The free ventilation of ships and goods coming from infected places, should also be attended to. It has been found, that fresh clay has great power in absorbing or destroying miasma. Perhaps it would be best not to pave the streets of the cities at all, or sometimes to plough up the pavements when the contagion seems generated in great quantities. But to conclude with this subject, I shall insert a letter which I wrote to Dr. Rush of Philadelphia, under the impression that it may contain an useful hint.

UNITED STATES NAVY-YARD,

New-York, 15*th June,* 1806.

Dear Sir,

YOU will, I hope, excuse my troubling you at this time with suggestions concerning the means of arresting the progress of the fatal epidemics, annually desolating the first cities of our country, as there is no person to whom I can communicate them with more propriety than to yourself. For what medical luminary has so long acted usefully on an extensive scale; by deviating from the practices of others; by shewing the citizens the error of their notions about yellow fever; the folly of dealing with measures of a marvellous kind for preservation, and the advantages of pursuing natural means, for securing natural ends?

Before leaving Virginia, I was firmly persuaded of the truth of the doctrines which you taught in the university concerning the malignant fever in this country. That it is a disease, the cause of which is generated at home, and not propagated by contagion, is so clearly true, that it is admitted and supported by most of the faculty, who do not oppose the doctrine solely with a view to preserve the favorable opinions of such wealthy and prejudiced persons as employ them : and indeed the doctrine is even rapidly gaining ground among all the citizens. The general desire at this time is, to discover means, not for avoiding importation, but for preventing at home the formation of that something, called miasma, and causing yellow or malignant fever. In the course of your labors, you have strongly recommended the removal of all collections of vegetable and animal matter disposed to putrefy. You have considered that the miasma, or cause of the fevers, was generated during the putrefaction of such substances ; and you have taught that the removal of these ; that the preserving clean the places frequented by the people, would secure the cities against malignant fever. Unfortunately for the health of the citizens, your advice has been but partially followed, and perhaps it cannot strictly be put in practice : for it seems almost impossible to remove all the putrefying masses from the cities at least while so many persons of careless and filthy habits, have so much of their own way.

To me, it appears highly probable, that the continued action of the light of the sun, has more influence in favoring the generation of miasma, than has hitherto been supposed. It has long been known, that in the animal and vegetable kingdoms, it produces most remarkable effects. But few persons are unacquainted with the facts, that the color of the skins of some animals is materially changed by exposure to light; that by the same means, white vegetables which have grown in the dark lose their whiteness, and have their mildest juices converted into the most active ; and that it is in consequence of the strong light within the tropics, that so many plants are spices and are very acrid. Surely these facts are more astonishing, than the production of that miasma by light which excites fevers.

No one will pretend to say that the malignancy of fevers is proportionate to putrefaction. It even seems likely, that the simple putrefaction of bodies, under common circumstances, such as the existence of heat and moisture, is not in reality injurious to men. In all woods, where heat and moisture abound, we know that putrefaction progresses constantly and rapidly; yet persons enjoy in them the best health, particularly in this country. During the unhealthy seasons, in the southern states, it is common, in some places, for gentlemen to remove from their towns and plantations into the thick woods, where they have houses slightly built for their reception: so generally is it known to be safe to reside in shaded places! Lands shortly after they are cleared, are also found to be healthy, although the putrefaction of animals and plants must be immense, from the suddenness of the alteration. It seems almost unquestionable that it is only after *long* exposure to the rays of the sun, that such a species of putrefaction takes place, as is characterized by the formation of the very active compound, causing the fevers which have lately proved so destructive in some parts of this country.

The theory advanced in my inaugural essay, of which you were pleased to express your approbation, led me to form an idea of the manner by which light, was directly instrumental in creating miasma. From the firm conviction of the truth of the position, it was without hesitation that I stated "that the form and properties of all compounds were acquired in consequence of the exercise of the chemical laws or affinities of substances, in the state, condition, or circumstances, in which they were placed"--- that of course "any material change of circumstances, was followed by a change of the properties of the substances placed in them," and that we were to learn by experience what particular circumstances were necessary to favor the production of any particular compound."

From the above considerations, I am led to conclude, that such is the peculiar nature of light, when it is strong and long continued, that it creates the particular circumstances in which the particles of putrefying matter of a certain kind, so combine, as to form a compound which acts on men and excites in them malignant and yellow fevers. Should it be asked, why this compound, called miasma, continues to be formed in the autumn, when circumstances are changed by the diminution of light—and what is partly necessary also, heat; the answer is, that such is the constitution or nature of things, that a ferment or chemical change once excited in any part of a mass, has a strong tendency to pervade gradually the whole of it, as is instanced in fermenting fluids, burning materials, and indeed in any body in which an alteration is wrought in one part before it is in another. When the light has been such, as to create that condition in which miasma is formed over any surface---an idea of it can be conveyed by observing that 'there is a miasmatic state.'---By this it will be understood that miasma exists: as the circumstances in which miasma is formed cannot continue, without the formation of it---and indeed the existence of the circumstances can only be ascertained by the appearance of the result, or compound.---Now the way to prevent the formation of such an active substance is to prevent the existence of the circumstances adapted for its formation. Inasmuch, therefore, as we have the power, it should be exercised in diminishing that light---favoring the production of deleterious substances where people dwell.

It might also be stated as generally true---that the activity of the miasma, formed during putrefaction, is proportionate to the intensity of the light in which the bodies putrefy. Hence in countries when the light is strongest, as in Egypt, the miasma excites the plague: in the towns of the United States, a less violent disease, the yellow fever; and in our counties, only the remittent and intermittent fevers.

In order, therefore, to preserve cities from the terrible epidemics, in addition to your wholesome advice of keeping them clean, by which much disagreeable stench will be avoided immediately, I would recommend shielding them from the action of the sun as well as can be done. Coarse and strong linen made in sheets, could easily be extended from the eves of the houses on one side of the street, to those of the other. These could be so constructed, that they might be readily removed in all boisterous weather. The expence and trouble would not be comparable to that of paving the streets, as it would require but a little addition to the awnings commonly over the doors of retail stores. But were the expence and trouble ten times as considerable, no man of enterprize and humanity would disgrace himself, by putting such considerations in competition with saving the lives of thousands. In a conversation on this subject, with which I was favored, with Dr. Miller, he suggested the advantages of having trees of large branches, at least in wide streets, where they would not impede the extinguishment of fires. These certainly must prove of great service; not however, as formerly supposed, by absorbing the miasma, but by preventing the light from favoring its production. Nothing can be more certain, than that some very good effects would be immediately produced, if the cities were shaded, at least in some manner more than they now are. The numerous deaths arising, as every one knows, from simple exposure to the sun, and the burning heats created by the reflection of light from the walls, would be avoided; while the laborers would do much more work, as well as the citizens in general, feel much more comfortable. These advantages appear sufficient to justify the adoption of my plan, independently of the fair prospect of preventing yellow fever. This prospect, however, inclines me to wish most ardently for the practice; for I believe it will prove successful. Measures less plausible, one would suppose, deserve a trial, for the restoration of that happy state of things, when the citizens will not annually be forced away from the scenes of business; or compelled to see such numbers prematurely consigned to their resting places. To imitate you, in quickening such a restoration, is one among the warmest wishes of

Dear Sir,
Your friend and servant,
THOMAS EWELL.

OXIGEN and nitrogen unite together in different proportions, and form compounds very different from atmospheric air; as will appear from the following:

By confining over mercury about four parts of oxigen and one of nitrogen air, on conveying the electric fluid through them, the base of the two airs unite together, and form a fluid, which is the *nitric acid* commonly called aqua-fortis. This fluid is again separated into the two airs of which it is formed in a strong heat, as was before stated. However, the nitric acid of the shops is not procured in this manner. It is generally prepared by putting two parts of common nitre or saltpetre, in a glass retort, with rather more than one part of sulphuric acid. On applying moderate heat the nitric acid comes over from the nitre, in the form of fumes, which are by water absorbed, constituting the nitric acid of the shops, which should be kept in glass vessels tightly stopt. The nitric acid is possessed of all the properties of acids, which have been enumerated, in an eminent degree. When pure, it is perfectly colorless, and its specific gravity is then 1.554. Exposed to the air it emits fumes of a white appearance, which imbibe moisture. As it contains a great quantity of oxigen, it supports the combustion of several substances. If poured on lampblack or oil, it burns; and if on the spirit of turpentine, it blazes rapidly. It emits heat on its union with water; but when added to pounded snow or ice, very great coldness follows. The combinations of this acid, called *nitrates*, will hereafter be considered.

When instead of four, you cause but three parts of oxigen to unite with one of nitrogen, then an acid is formed which is not so strong as the nitric, and which is called *nitrous acid.* The nitrous acid may be prepared by distilling the nitric, which in a high heat parts with some of its oxigen. This acid differs from the nitric in being of a yellow or orange color, and in emitting copious red fumes. When concentrated, its specific gravity is about 1.580. When united to other bodies, they are called *nitrites*, which, as they are not of much consequence, will not be considered.

When but two parts of oxigen are chemically united to one of nitrogen, then an air is formed, called nitrous air. This air is generally prepared by pouring diluted nitric acid on wires of copper, in a glass retort, connected to the pneumatic apparatus. When heat is applied, the nitric acid parts with half its oxigen to unite with the copper, and the nitrous air comes over, a colorless and permanently elastic fluid, which must be kept over water. This nitrous air is incapable of supporting life, vegetation or combustion. Its most remarkable property is, the facility with which it unites to oxigen; as whenever they come in contact, they unite, and form the red fumes of nitric acid. In consequence of this property, it was proposed to be used in ascertaining the quantity of oxigen air present in atmospheric air; to a given quantity of the air in a vessel, over water, is to be introduced nitrous air, which on uniting to the oxigen, forms nitric acid, which is absorbed by the water; so that the diminution of bulk will be proportionate to the quantity of oxigen that had been present. But this method is found too fallacious to be relied on.

When about one third oxigen and two of nitrogen are united together, they form an air called *nitrous oxid.* This air is prepared commonly by heating the nitrate of ammonia. It is capable of supporting animal life and combustion. Lately it attracted great attention; but has since been found not entitled to it from its properties.

From what has been stated, it appears that oxigen and nitrogen are capable of uniting to each other in five different proportions. According to the most accurate experiments the exact proportions in which they combine are thus stated:

		Oxigen.	Nitrogen.
100 parts	of nitric acid contain	73 parts	27
do.	of nitrous acid,	68	32
do.	of nitrous air,	56	44
do.	of nitrous oxid,	37	63
do.	of atmospheric air,	24	76

OF WATER.

AS introductory to the consideration of another species of air, I must deliver a few remarks concerning water; a fluid universally acknowledged to be of the utmost importance in the animal, vegetable, and mineral kingdoms.

Every one knows, that it exists in three states in nature, in the forms of vapor, common water, and ice.

Whenever the degree of heat is below 32°, water is changed into the solid called *ice*. This conversion is called freezing. During its freezing, it undergoes an expansion, which has, in some instances, been found sufficient to burst a cannon. The expansion arises partly from the extrication of the air contained in the water, which appears in bubbles, and partly from the particles of the water being differently arranged, so as to occupy a larger space. This new arrangement of the particles of water, is in consequence of the exercise of its affinities or laws in a low heat.

Water is also made solid in other states. It unites to a variety of substances without diminishing their solidity. When poured in small quantities on fresh lime, it unites to the lime, and may afterwards be procured, by heating the lime in close vessels. Many bodies, when assuming their respective shapes, which has been called, as before observed, *crystallization*, unite to water in considerable quantities; as for example, saltpetre, common salt, Glauber's salts, &c. This is called the water of crystallization. It may be separated by exposure to high heat.

On increasing the degree of heat beyond 32°, ice or solid water, is then changed into fluid water. During this change, a capacity is acquired to absorb sensible heat and convert it into latent heat. As was before observed, this heat is not to be considered as the cause of the fluidity.

In this state water acts as a powerful agent all over nature. It gives fluidity to innumerable substances. It exerts a strong attraction for a variety of bodies, unites to them, or in other words, dissolves them. This capacity, or power to dissolve them, is generally much increased when the temperature is increased, as was noticed while considering heat.

In a high temperature, the water takes on the properties of an air, generally termed steam or vapor. During this change, a quantity of latent heat is absorbed, as was the case in the last instance; and, as was mentioned while considering heat. This conversion of water into vapor goes on at every temperature, but with different degrees of rapidity, as every one knows. It is very much influenced in this change by the pressure of the atmospheric air. Under the common pressure of the air it takes place very rapidly at the degree of heat marked 212; and then the water appears in the state called *boiling*. This boiling, however, may be produced in a much less heat, if the pressure of the air be lessened; as on the mountains, or by the use of the air-pump. When the water is converted into vapor, it undergoes a prodigious expansion, and thereby produces the powerful effects observed in the various steam engines.

Water, in the state in which we commonly procure it, holds a great variety of substances in solution. In snow and rain-water, there are great quantities of atmospheric air, and such is called *atmospherical water*. This air is found more or less in all water, and gives to it an agreeable flavor. The water of springs is called *soft water*; it is called *hard water*, when it contains neutral salts; and *mineral water*, when it contains large quantities of mineral productions. The examination of mineral waters will hereafter be attended to.

In order to free water from all the impurities, with which it is blended mechanically, it should be put in a tub, the end of which should contain a little straw, on which should be placed charcoal finely powdered, about one foot thick. A small orifice should be made at the bottom, through which the water as it comes down may be drawn off for use. Lately it has been found, that the most putrid and filthy water can, by these means, be rendered perfectly pure and palatable. Now, as it can be done so readily, and without expence, it would be well for all those who have hitherto been obliged to use bad water, to purify it before use. Masters of vessels, particularly, ought to keep a tub constantly with charcoal in it, for the purpose of purifying their water, at least when long at sea. It would be instrumental, probably, in saving the crews from much sickness.

But, when water is chemically combined with substances, as sea-salt, saltpetre, &c. it can only be purified by distillation. For this purpose, a common still will answer. If there be a little management in the fire-places of ships, the same heat which answers for cooking, will answer for the distillation of sufficient water, from sea-water, for the purposes of ships. Lately patents have been given for apparatus of the kind, which any man would suggest, who would attend to the subject. Water, when distilled, is found to have a particular taste which is disagreeable. This arises from the want of atmospheric air; the defect may be readily remedied, by agitating the water in casks half filled, and containing uncorrupted air.

From observing the agency of water throughout nature, it was considered by ancients as an elementary body. It was only a few years since, that the most important discovery was made, shewing that it is a compound. This has enabled chemists to account for many phenomena, which were formerly deemed inexplicable. That it is a compound substance, is proved by the following

EXPERIMENT.

Introduce up near the touch-hole of a gun-barrel, iron wire, or a quantity of iron filings free from all rust. To the touch-hole, attach a small tube for the purpose of admitting water. Properly connect the mouth of the gun-barrel, with the pneumatic tub for the collection of airs. Then let the body of the barrel go through a grate, in which there is a sufficient fire to make it redhot; particularly that part where the filings of iron are to be well heated. Then, on introducing water at the tube in the touch-hole, it is converted into steam, and decomposed, one part uniting to the iron, the other escaping in the form of air, and rising in the bell-glass. This process being ended, on examining the filings of iron, they will be found to appear *rusty*. If they be introduced into the gun as before, the touch-hole stopped, and a strong heat applied, an air will come over, which will be found to be pure oxigen air; and, on examining the filings, they will be restored to their metallic state. If 100 parts of water have been used, there will be found 15 parts of the air first coming over, and 85 of the oxigen air last procured. Now, if these two airs be mixed together, on applying heat they burn, unite together, and form the 100 parts of water originally used. This then must prove, most satisfactorily, that water is a compound, formed by the union of 85 parts of oxigen air, and 15 parts of another air, called hidrogen air, which must now be considered.

Hidrogen is the name applied to the base of hidrogen air, in consequence of its being one of the constituents of water. This base is an elementary body, and has only been found in a state of combination. It exists in greatest purity in hidrogen air. Hidrogen air is the lightest of all known bodies; it being, when pure and dry, 13 times lighter than atmospheric air. In consequence of this, it is used to raise balloons. If, on introducing any burning body in this air, without allowing the admission of oxigen, the body is instantly extinguished, and also animals expire when put in it. Therefore the air is incapable of supporting combustion or life. If, however, fire be applied to the air, in the presence of oxigen, the air quickly burns; therefore it is inflammable, or combustible. In this case the bases of the airs unite and form water, at the same time throwing out heat and light. If a vessel be filled with this air, and kept with its mouth downwards, on applying fire, it gradually burns. If in an oval tin vessel, holding less than a pint, be introduced one part of hidrogen air, and two of atmospheric air, on applying fire at a small orifice, the union between the oxigen and hidrogen is so instantaneous, that a prodigious noise is made by the sudden condensation of the airs. If one part of hidrogen and two of oxigen air be mixed together, as above, on applying heat the union is still more instantaneous, and the noise equal to that of a cannon. In making these experiments, it would be well to have the hand holding the vessel wrapt up in a handkerchief.

A number of curious experiments are frequently made with this air. The artificial fire-works exhibited occasionally in the cities, are made by collecting this air in bladders, or bags of silk varnished, which have tubes of different sizes leading from them in various directions, through which the air is pressed out. When it comes to the orifice, fire is applied, the air blazes, without smoke, and continues to do so until all is burnt, thereby exhibiting a most beautiful and brilliant spectacle, if judiciously managed.

Hidrogen air is procured for the purposes of experimenting, always by the decomposition of water. This is sometimes done in considerable quantities by means of the filings of iron in a tube, as above described. But more generally the air is collected by pouring sulphuric acid on bits of iron or zinc, diluted with four or five times its weight of water. To the vessel containing this mixture a tube must be attached, properly connected to the pneumatic tub. The air will then come over in the bell-glasses, rapidly, and in quantities regulated by the quantity of the articles used.

This air is sometimes found pure in nature, and it no doubt arises from the decomposition of water. It issues from some springs and caves, at the mouths of which it burns when fire is applied. It is extricated sometimes in mines, and is known to miners by the term *fire damp:* sometimes it proves destructive to them. In such cases the air should be burnt, or conveyed off by means of pipes. In large marshy places, hidrogen air is frequently extricated, and when set on fire by the electric fluid, exhibits the singular phenomena, called *Jack with a lanthorn.* When the air escapes to upper regions and is there burnt, it gives rise to that blazing in the sky called meteors; and no doubt its combustion, and the consequent formation of water, is the cause sometimes of sudden falls of water.

Hidrogen is one of the most important elementary bodies. It aids in the formation of many compounds, hereafter to be considered.

DISCOURSE IV.

THERE is a substance existing in immense quantities and diffused throughout nature which is known to chemists by the term carbon. It exists only in the pure state in the *diamond*. However, it is the chief substance forming plumbago or blacklead, pit, stone, or mineral coal, the remains of burnt vegetable bodies, called *charcoal*, and a great variety of other compounds, as will hereafter appear. The peculiar and distinguishing property of this elementary substance is, that it unites to oxigen, and forms an air, formerly termed fixed air, but now more properly, carbonic acid, gas or air; also to iron, thereby converting it into steel or a *carburet of iron*.

Carbon exists pure, and free from combination in the gem, called diamond. Its properties in this state are familiar to most people. It was well known to our ancestors, and is principally found on the western peninsula of India, on the coast of Caromondal, in the kingdoms of Golconda and Visapour, in the island of Barneo, and in the Brazils. They are generally found bedded in yellow ochre, or in rocks of free-stone or quarts, and sometimes in the beds of running waters. When taken from the earth they are found covered with a crust of earth and chalk.

Diamonds are *generally* crystallized, and shaped as an eight sided prism. They appear to be formed of thin plates or *lamina*, which are split or cleft with an instrument of tempered steel, by a swift blow in a particular direction. They are the hardest bodies in nature, which renders it necessary to attack them with diamond powder. In consequence of this, they are used to engrave stones and cut glass. They take an exquisite and lasting polish. They have a great refractive power, and consequently uncommon lustre. The usual color, is a light grey, often inclining to yellow, at times lemon color, violet or black, more seldom rose-red, and still more rarely green, or blue, but more generally pale brown. The purest diamonds are perfectly transparent, and their specific gravity is to that of water as 3.512 to 1.000.

Diamonds do not combine with other bodies, excepting iron and oxigen; and for it to unite with these a most intense heat is requisite. When most intensely heated in a close vessel with iron they unite together and form steel, as has been proved by Morveau. In a high heat in the presence of oxigen air, it burns with a sensible flame, but slowly, and then forms carbonic acid. From this it is concluded that diamonds are pure crystallized carbon.

The great Newton was the first, who, from the refractive power of diamonds, inferred that they were combustible. His conclusion has since been proved to be correct, by several experiments performed by different persons. The Emperor Francis I. exposed to a vehement heat, the value of 6000 florins in diamonds and rubies; the diamonds disappeared, but the rubies remained unaltered. The Grand

Duke of Tuscany had similar experiments performed, with the same success; and also the French chemists, Darcet, Cadet, Lavoisier, and Guyton Morveau. Lavoisier proved, that like all other combustible bodies, it burnt just in proportion to the quantity of oxigen presented to it; and that the product was carbonic acid, the same which is formed from the combustion of common charcoal. Guyton Morveau, placed a diamond in a China cup, surrounded with oxigen air, which was confined in a proper apparatus. He then applied the focus of a great lens, by which most intense heat was excited. He first observed on the diamond a black point at the angle struck directly by the solar rays; after this, it soon became completely black, and of a coally appearance; the instant afterwards brilliant, and as it were boiling points were distinctly perceived. It now began to diminish in size, and in a short time, only one fourth remained; which was shortly after consumed in the same manner. The air formed, when conveyed over lime-water was absorbed by it and rendered it turbid, which shewed that it was carbonic acid. Dr. Tennant, by heating diamons in a gold vessel, with nitre, occasioned them to burn and form carbonic acid as above, in consequence of uniting to the oxigen of the nitre.

Carbon is found in nature, united to oxigen and other bodies in various proportions. Plumbago or black lead is carbon, united to a little oxigen and iron. By uniting it to more oxigen by combustion, this substance is converted into carbonic acid. For it to burn, however, it requires a most intense heat; and in consequence of this, vessels used in strong fires are very properly made of it in some places. The incombustible pit-coal, as it is termed, is nearly the same as plumbago.

Next to these substances, the combustible mineral coal called also pit, sea, or stone-coal, contains most carbon in a given bulk. They contain more oxigen than plumbago, and consequently burn so readily, that they are generally used for fuel. Most commonly these coals contain a little sulphur, iron, clay and other substances: but their combustibility certainly depends chiefly on their carbon; as, while burning, the greater part unites to oxigen, and escapes in the form of carbonic acid air.

COMMON CHARCOAL.

When common wood is burnt so that the air does not circulate about it very freely there is a black substance left, called *charcoal*. The quantity of charcoal yielded by different trees varies considerably; black ash is said to yield 25 parts of it in the hundred; guiacum 24, green ash, 20, &c.--- The charcoal commonly found is impure from several combinations. But from whatever wood it be procured, it may be made pure by heating it red hot in a close vessel and allowing the airs to escape. The charcoal so treated, has a very strong attraction to water; is of a very black color, is porous and capable of burning quickly, so as to be entirely almost converted into carbonic acid. It resists putrefaction very much, and in consequence of this all posts which are introduced in the earth should be burnt or charred over, as is now only occasionally done. Fresh charcoal completely destroys the disagreeable odour of clothes, when folded up in it. As before observed, it purifies the most fetid water. When boiled with tainted meat, it takes away the taint entirely, and it also corrects the rancidity of butter when melted. When powdered, it is the best tooth-powder in use, and corrects disagreeable breath in a great degree. It is a most excellent application to old ulcers; it not only corrects their horrid smell, but aids in healing them. I have cured an ulcer on the chin by applying it, which had resisted all the remedies prescribed by other physicians, and which was deemed cancerous. I also administered it to a near relation affected with heart burn, with success. It has a happier effect in correcting fetid and acrid stools than chalk, and consequently should be taken by those laboring under billious fevers. When finely powdered, it is used to fatten fowls, and as a manure it is also of great value if reduced to very fine powder.

AERIAL OXID OF CARBON.

If charcoal be made redhot in a retort with the rust or oxid of iron and connected with the pneumatic tub, a very light inflammable air will come over which was erroneously for sometime taken for hidrogen air. This air is called aerial oxid of carbon.

LIGHT CARBONATED HIDROGEN AIR.

Carbon also unites to hidrogen air, and forms an air called *light carbonated hidrogen air*. This air may be procured by introducing redhot charcoal underneath an inverted bell-glass filled with water: the air rises to the top, and then to be freed of carbonic acid, should be agitated over lime water. It burns with a blue flame. After it is burnt, the products are water, and carbonic acid as must readily appear. This air is extricated about marshes, ditches, and putrid water. It may be formed by keeping hidrogen air over charcoal in the sun; also, by heating moistened charcoal, or sawdust in a retort connected with the pneumatic tub.

HEAVY CARBONATED HIDROGEN AIR.

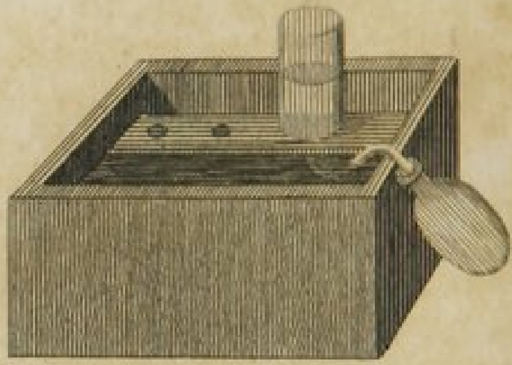
Chemists have observed that there is another kind of air formed by the union of carbon and hidrogen.--- This is called *heavy carbonated hidrogen air*. It is procured by several means: one of which is by allowing ether or alcohol to pass through a redhot earthen tube. This air is inflammable, is fetid, and is most remarkable for being converted into an oil, when four parts of oxi-muriatic acid air are added to three parts of it, and agitated over water. It contains more carbon than the last named air.

CARBONIC ACID.

When oxigen is fully saturated with, or combined to carbon, the well known compound is formed, which has been called aerial acid, fixed air, mephitic air, but more pro-

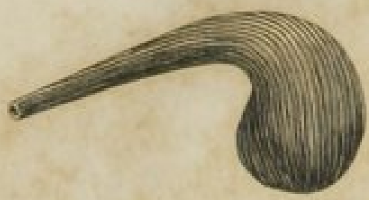
For Doctor Ewell's Discourses.

Fig. 1.



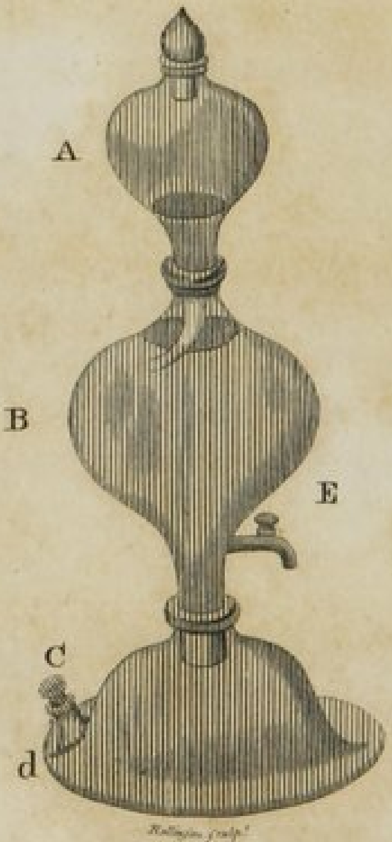
A Pneumatic Apparatus or Tub.

Fig. 2.



A Retort.

Fig. 3.



Doct.r Nooths Apparatus

Publish'd by Brisban & Brannan New York. 1806.

perly *carbonic acid*. According to Lavoisier this air is formed of 28 parts carbon and 72 oxigen. Carbonic acid exists in great quantities in nature, in an aeriform, and in a combined state. It is among the heaviest airs known; its specific gravity being to that of atmospheric air, as 1500 to 1000, so that it can be poured out of one vessel into another.--- This air may be collected in vessels, by emptying bottles of water when it exists, in caves or in tubs where beer or wine ferments. Or it may be had by burning charcoal in pure oxigen air; or pouring sulphuric acid on chalk, and receiving the air as it escapes, causing the effervescence in bladders, or in the pneumatic tub. When it is collected it will be found possessed of the following properties: it is invisible: it extinguishes burning bodies introduced in it, and it is fatal to animal life. It exerts powerful effects on living vegetables. Its taste is pungent, and in a small but certain degree it possesses the properties of acids. It precipitates lime from lime water, by uniting to the lime, and forming white chalk, which is insoluble. It is readily attracted by all the alkalies. At common temperatures it is not acted on by any substance; but iron, phosphorus and lime decompose it in a strong heat by uniting to its oxigen.

Carbonic acid unites to water, and gives it the properties of an acid: after agitation in it, the water absorbs considerable quantities. The colder the water and the greater the pressure applied, the more of the acid will be absorbed. The common method of impregnating water with it, is through the medium of Nooth's apparatus, which is represented in plate 2, fig. 3. A is the upper vessel, whose neck reaches nearly to the centre of the middle one B, which last is half filled with water, and has at C a glass valve which is kept down by the pressure of the water. At D the materials are put in; these are generally diluted sulphuric acid and chalk, from 3 to 9 ounces of each. This must be done cautiously or the glass will break from the heat extricated. The ingredients being added, the sulphuric acid unites to the lime contained in the chalk, which consequently gives up its carbonic acid. This acid air raises the valve at C, passes through the water and unites to it. The water is then drawn off at the cock E. In this state the water is found to possess the properties of an acid. It sparkles upon agitation as cyder, perry, porter, champaign, &c. which arises in each case in consequence of the extrication of the carbonic acid or fixed air. Water impregnated with carbonic acid is used as a medicine, in affections of the stomach, kidneys, &c. with great advantage. It has also been injected in the bowels with the happiest effect in nervous fevers. The water as well as all the fermented fluids which contain this air, may be freed of it by warming them. A bladder attached to the mouth of the vessels containing it, will retain the air for examination.

There are but few airs more commonly met with than carbonic acid. At least one hundredth part of our atmosphere is invariably found to be this air, and in some places it exists in much larger quantities. It is often found occupying the lower parts of mines, caverns, tombs, vaults, wells, and such other places as contain materials for making it; and it is then called, *chalk damp*. The famous grotto del Cano, near Naples, has long been known, for the quantity of this air which it produces and which runs out at the opening, like a stream of water. The quantity formed in this cavern is so great, that a dog or any animal is soon killed, if his nose be thrust into it. The lake of Averno, where Virgil placed the entrance of hell, yields so large a quantity of this air, that birds cannot fly close over it with safety. Immense quantities of this air are always formed during fermentation, and on account of its great weight, occupies the apparently empty space, or upper part of the vessel, in which the fermenting process is going on. In consequence of the extrication of this air in cellars, where beer, wine, &c. ferments, persons are frequently suffocated on entering them, or in other words are *drowned in an air not respirable.* During the combustion of every species of wood this air is formed in great quantities, and being rarefied by the sensible heat, is carried off. Sometimes however, in close rooms, it does not escape; and falling on the floor it collects in such quantities as to prove fatal to those confined in it. To avoid unhappy accidents, a burning candle should be introduced in the suspected places, and if it be extinguished, as elsewhere observed, the air will not support life. An infallible test to determine if the air be carbonic acid is lime water, which absorbs the air forming chalk that gives the water a turbid appearance. However, if a *great* quantity of the acid be added to this turbid mixture, the *chalk* will be absorbed.

This acid exists in combination with a variety of bodies, which are called *carbonates.* Every soil contains more or less of it. When a strong acid is added to any earth, if it effervesce, it is in consequence of the escape of this air. The substances with which it is combined must be hereafter considered.

SULPHUR.

THE next important elementary substance which claims our consideration, is called sulphur, or brimstone. It was early known to our ancestors, and is presented by nature in a pure state It is found in the earth, also, in various states of combination, particularly with the metals, forming the great variety of ores called *pyrites*. About volcanoes, it is uniformly met with in great quantities, and sometimes on the surface of waters. It also exists in vegetable and animal substances.

Sulphur is universally known to be a very combustible and brittle substance, of a pale lemon yellow color. Its specific gravity is 1.900. It is destitute of odour except when rubbed or heated, and has a peculiar faint taste. If a piece of it be gently heated, as for example, by holding and squeezing it firmly in the hand, it breaks to pieces with a crackling noise. It is a non-conductor of electricity, and hence it becomes electric by friction. When heated, it first softens, then melts at 184°, is volatilized at 289°, and burns at 302°. In the beginning of the fusion it is very fluid, but by continuing the heat, it grows tough and appears of a reddish brown color. If in this condition it be poured into water, it remains as soft as wax, and this is sometimes used to receive impressions from seals. Sulphur unites with most of the earths, all the alkalies, and most of the metals, which last it renders brittle and fusible. It is soluble in oils, water takes up a small quantity of it, and also ardent spirit by means of heat. It dissolves in hidrogen air, forming a most fetid air, and unites to phosphorus. When heated in a close vessel it sublimes without alteration; nor is it changed by long exposure to air.

Sulphur is procured for commerce in prodigious quantities from some volcanic countries. Great quantities of it are prepared at Solfatara in Italy. This volcanic country every where exhibits marks of the agency of subterraneous fires; almost all the ground is bare and white, and is every where much warmer than the atmosphere in the hotest weather. This favors the suggestion mentioned while considering the extrication of sensible heat, that the volcanoes arise from chemical changes between sulphur, iron and water. The method of obtaining the sulphur for commerce is generally as follows.

Pyrites (which is a mineral formed by the union of a metal and sulphur) is broken into small pieces, and put into large earthen tubes which are exposed to the heat of a furnace. A square vessel of cast iron containing water, is connected as a receiver to the furnace by a tube. The action of the fire proceeds, and the sulphur being thus melted, is gradually accumulated on the water in the receiver. It is then removed from this receiver, and melted in large iron ladles, in consequence of which its earthy parts subside to the bottom, leaving the purified sulphur above. When again melted and allowed to cool gradually, it forms the masses of sulphur met with in commerce. In order to form this into rolls, it is again melted and poured into round wooden moulds, the form of which it takes, and in this state they are sold in commerce as *roll sulphur*.--- *Flowers of sulphur* as they are called, are formed by subliming purified sulphur with a gentle heat in close rooms, where the sublimed sulphur is collected, though the article met with in general under that name is nothing but sulphur finely powdered.

Sulphur, like all combustible bodies, burns in proportion to the quantity of oxigen which combines with it. It is capable of uniting to two doses of oxigen. If melted sulphur be exposed to the air while heated it takes fire, burns with a blue flame, and emits a suffocating vapor. This is the *sulphureous acid air*. It is possessed of all the properties of acids. It is heavier than atmospheric air, and assumes a concrete form when made cold. It is absorbed by water in considerable quantities. It is composed of about 85 parts sulphur and 15 oxigen. United to an additional quantity of oxigen, it forms sulphuric acid. It unites to other bodies and forms *sulphites* which have not been much attended to.

When sulphur is fully supplied with oxigen, it then forms a different and much stronger acid, called *sulphuric acid*. This is an article sold in the shops commonly by the name of *oil of vitriol*, and is much employed in commerce. It exists in immense quantities formed in nature. Manufactories for its preparation are established in different places. Usually it is thus formed: Rooms lined with sheets of lead are prepared, and in the bottom a small quantity of water is placed. Nine parts of sulphur and one of nitre are then put in the centre and fire applied, when the room is closed. The sulphur then unites to the oxigen of the nitre and forms fumes, which run down on the walls, and unite to the water for which they have strong attraction, then constituting the *oil of vitriol of the shops*, or the *sulphuric acid*, in an impure state. It is then subjected to distillation in glass vessels. After this it is found of an oily consistence, transparent, and possessed of all the properties of acids in an eminent degree. When it unites to water, much latent heat is set free. The principal use of this acid is in dyeing, in which art it serves to dissolve indigo and carry it in a state of extreme division upon the stuffs to be dyed. The chemist makes great use of it in decomposing bodies. And physicians administer it as a tonic in very small doses diluted with water and ardent spirit, forming the *elixir vitriol* of the shops. It has also been used as a manure. Its combinations which are of great value, with other substances forming *sulphates*, will be hereafter considered.

As before observed, sulphur unites to hidrogen air, and forms a very fetid air, which has some remarkable properties. This union may be effected in several ways. The most direct method is, to confine the air over sulphur, and heat it by the focus of a lens. This air contains about one eighth sulphur, and is called *sulphurated hidrogen air*. It is an inflammable air, and when burnt, the products are water and sulphuric acid. It is partially soluble in water, to which it gives a most nauseous taste. It is extricated from rotten eggs, and is the cause of their disagreeable smell. It is most remarkable for reddening several vegetable colors, in which it resembles acids. The electric fluid when conveyed through it, causes the deposition of the sulphur.

Sulphur may be combined with the metals, by heating it with them. The compounds formed are called *sulphurets*, which must hereafter be attended to. During its union with some of them, as copper and iron, although no air be admitted, there is an emission of light, as first noticed by the Dutch chemists, and as mentioned while considering electricity. This, as before stated, is to be attributed to the conversion of latent into sensible electricity, which consequently escapes, throwing out the latent light of the air.

OF PHOSPHORUS.

THERE is a simple elementary substance which, like carbon and sulphur, is combustible, and by its union with oxigen forms an acid. In consequence of this I shall here consider its properties. It is known by the term *phosphorus*.

Phosphorus has never been found pure in nature; it is met with united to oxigen forming phosphoric acid. In that state it exists very plentifully in several animal, mineral andvegetable substances. When freed from its combinations, it is of a flesh color, of the consistence of wax, but brittle in cold weather. In atmospheric air it is luminous at common temperatures without emitting heat. It has a rough disagreeable taste, and its odour is like that of garlic. Its specific gravity is 2.033. Exposed to the light, it becomes covered with a crust, which is first white, next orange, and then red. It becomes liquid at a temperature of 99° and at 122° it burns rapidly, with a brilliant white flame, and by its union with oxigen is converted first into phosphorous acid. Expressed and essential oils take up a small quantity, and also ardent spirit and ether. It combines with lime, sulphur and the metals. It acts strongly and frequently like poison on living animals.

The process for obtaining pure phosphorus usually employed is as follows: Collect a quantity of urine, and pour on it a strong solution of the nitrate of lead until it ceases to produce cloudiness. The mixture is then to be diluted with water, and allowed to rest undisturbed so that the precipitate may all subside. This being done, the clear fluid is to be separated, and the precipitate, which is a phosphate of lead, is to be made in a paste with charcoal, and dried gradually. It is then to be put in a glass vessel with its mouth in water, when heated, the carbon unites to the oxigen of the phosphoric acid, and forms carbonic acid, which escapes. The phosphorus afterwards comes over and falls to the bottom of the water, in an impure state. It may be purified by a second distillation.

Phosphorus is frequently, also, obtained from the bones of animals. For this purpose, the bones are burnt to whiteness, and reduced to a fine powder. After putting three pounds of this powder in an open glass vessel, pour on it two pounds of strong sulphuric acid, and gradually add 4 or 5 pounds of water. The operator must avoid inhaling the fumes which arise. The whole should then be kept gently heated for about 12 hours more, taking care to add water to supply the loss of that which evaporates. The next day a good deal of water must be added, the clear fluid poured off, and the rest strained through a cloth, and water poured on it till it passes tasteless. The whole of the liquor should then be evaporated to the consistence of syrup in a flat earthen bason. It is then to be mixed with an equal quantity of charcoal powder, distilled as above, and the phosphorus will come over. Phosphorus so obtained is usually prepared into sticks or rolls. This can be done by taking a long necked funnel, stopping the lower orifice, filling it with water, and then adding the phosphorus and introducing the whole in boiling water. The phosphorus melts and runs down in the neck of the funnel. The whole is then to be removed to cold water, the stopper withdrawn, the phosphorus thrust out and preserved under water in vials tightly stopt.

The combustibility and luminous property of phosphorus have given rise to various amusing experiments, some of which evince its properties very clearly.

The names of persons written on walls with phosphorus have at night, for some time, a very luminous appearance, in consequence of the combustion. In writing with phosphorus, it is very apt to burn briskly, and should therefore be inclosed in a tube, and also be frequently introduced in cold water. *A phosphoric fire bottle* is prepared for travellers by heating a small thin vial, and introducing in it bits of phosphorus successively until it is filled, taking care each time to stop the vial after it is introduced. Another method of preparing this bottle is, by heating together equal parts of lime and phosphorus, in a loosely stopped vial for half an hour. Afterwards these vials are to be kept tightly stopped. To use them, they are uncorked and a common match or bit of wood tipped with sulphur is to be introduced, turned round, and quickly drawn out, which then takes fire instantly. One part of phosphorus and 8 parts of sulphur, when heated and mixed together in a vial, form a very inflammable compound, which when taken out with a match and rubbed on a cork inflames readily. When phosphorus is dissolved in oils, it forms what is called liquid phosphorus. The best method of preparing it is to boil gently one part of phosphorus with six of oil of olives, which is to be kept well stopped, when opened at night it partially burns, and gives out light sufficient to show the hour of the night when a watch is held near. It may also be used for forming luminous drawings by means of a brush, and it may be with safety rubbed on the hands and face to give them a luminous appearance at night. Phosphorus is also soluble in water. If a small piece of it be put in a flask with water and heated, many various appearances, resembling the *aurora borealis*, will follow. This is in consequence of the solution of the phosphorus in the steam, which takes fire when coming in contact with the air as it rises.

Phosphorus unites to a variety of other bodies, forming *phosphurets*, which, however, are not of great importance. The one that has been most attended to is called *phosphuret of lime*. This is formed by the direct combination of lime with phosphorus, in a tube closed and strongly heated. Phosphorus, like carbon and sulphur, unites to hidrogen air, and forms an air called *phosphorated hidrogen air*, which is remarkable for being so combustible that it readily burns whenever in contact with atmospheric air. This air is formed, by adding phosphuret of lime to water, by which the water is decomposed, and its hidrogen escapes with the phosphorus, which instantly burns on coming to the surface. This air is also extricated about grave yards, putrid fish, &c. It is the cause of their smelling so insupportably.

When phosphorus unites to but a small quantity of oxigen, it forms the acid called *phosphorus acid*, which is a volatile, transparent, and dense fluid. It unites to other bodies, forming *phosphites*, which have not been much attended to.

When phosphorus fully combines with oxigen it forms the acid called *phosphoric acid*. This acid may be formed by the rapid combustion of phosphorus in oxigen air; or by pouring on it nitric acid in a gentle heat, which parts with its oxigen to unite with the phosphorus. This acid is capable of existing in a dry and crystallized state. When solid and placed in contact with water it dissolves and affords a ponderous transparent fluid void of odour. It unites to other bodies forming compounds called *phosphates*, which will be considered in their proper places.

HAVING considered the three elementary substances, carbon, sulphur, and phosphorus, also, the acids they form when combined with oxigen, it will be proper in this place to treat of three acids which are found in nature, and which in consequence of their not having been decomposed, are deemed elementary bodies. They are the muriatic, the fluoric, and boracic acids. It is only from analogical reasoning that it is concluded they owe their acidity to oxigen.

THE MURIATIC ACID.

THE muriatic acid exists in great abundance in nature in combination. United to soda, it forms common salt, which gives the saltish taste to sea water, and which forms immense mountains in some places. The acid may be had pure by the following means in the state of an air :

Put into a retort two parts of dry common salt (which is properly called muriate of soda) and gradually pour on it one part of strong sulphuric acid. The sulphuric acid unites to the soda, and the muriatic acid escapes in the form of air, which should be received over mercury.

Muriatic acid air, has a remarkable strong attraction for water. This is so considerable, that whenever they come in contact, they quickly unite, forming the *muriatic acid* of the shops, called also *spirit of sea salt*. The air has a very pungent and suffocating odour, which excites coughing. It is readily absorbed by ardent spirit, ether, fat, and essential oils, melted wax, phosphorus, and many other bodies. It is possessed of all the properties of acids. It suffocates animals and is so very caustic as to excoriate the skin. It extinguishes a lighted taper, the flame of which becomes green, or rather light blue, at the upper part. Light has no effect on it ; heat rarefies it. It is heavier than common air, its specific gravity being to that as 1.750 to 1.000 ; when brought in contact with oxigen air, it forms a white cloud. Ice is melted by it as speedily as if thrown upon the fire. It unites to oxigen forming the *oxi muriatic air*. It destroys miasma. It combines with a variety of substances forming *muriates*, which will elsewhere be considered.

When muriatic acid becomes combined with a certain quantity of oxigen, the compound is called *oxi muriatic air.* Its union, however, with oxigen does not increase its acidity. This remarkable air may be procured as follows:

Put into a retort one part of the black powdered manganese which is sold by the potters, and add to it three or four parts of the strong muriatic acid. Connect the retort with a pneumatic tub, and receive the air over water in the usual manner. When the air ceases to come over, apply the heat of a lamp, and it will come over in larger quantities. The air may be kept in bottles with glass stoppers.

This acid may also be obtained in an indirect manner, by decomposing muriate of soda or common salt, in contact with black manganese. For this purpose, mix eight parts by weight of salt, with three of the manganese, put the mixture in a retort, and gradually pour on it diluted sulphuric acid, on applying a gentle heat, the air will be liberated. In each of the above experiments, the oxigen is yielded to the muriatic acid from the black manganese, which contains much of it.

When two parts of the nitric and one of the muriatic acid are added together, the nitric acid parts with its oxigen to the muriatic, and the oxi muriatic acid is formed. This is known by the name *aqua regia*, and it excited a great deal of attention in consequence of its power of dissolving gold. It is called by some chemists nitro-muriatic acid.

The properties of this air, are: It possesses an uncommonly pungent and suffocating odour. It destroys miasma. It is very destructive to animal life, particularly if not diluted with common air. It is absorbable by water and forms with it, what is called liquid oxi muriatic acid. It has a yellow greenish color. It is capable of maintaining and exciting combustion in many cases. Phosphorus, charcoal, bismuth, iron, zinc, copper, tin, lead, and some other combustibles take fire spontaneously when introduced in it. It thickens fat oils. If yellow wax be exposed to its action, it is bleached. It destroys most vegetable colors, or renders them white. If to a solution of it in water, colored callico be added, all the colors except the yellow are destroyed; in consequence of this property of bleaching, it is coming into general use for the purpose. When applied either in the liquid or aeriform state, to thread, cotton, linen, wax, &c. to a very surprising degree, and in every season of the year it renders them white. After clothes are dipped in it, they should be washed in ley, to destroy their bad smell. This acid unites to other bodies forming compounds termed *oxi muriates* which have excited a little attention.

FLUORIC ACID.

THE second acid which chemists have not been able to decompose, is called the fluoric. It does not exist in large quantities in nature. It is found in combinations only, and united to lime, forming *fluate of lime*, or *Derbyshire spar*. It is obtained in the state of an air as follows:

Put one part of powdered fluate of lime into a leaden or tin retort, and pour over it two or three parts of strong sulphuric acid. A violent action instantly takes place. The sulphuric acid unites to the lime, and the fluoric acid rises in the form of air. This air is to be received over mercury in a metallic vessel, or in a glass receiver lined with wax or varnish. A gentle heat will cause the whole of the air to be extricated.

The properties of this acid are: It dissolves silex, and keeps it suspended in the aeriform state, and is consequently used to dissolve glass, crystals, and various precious stones. These are, however, deposited when the air is absorbed by water. It is heavier than atmospheric air. It is not fit for respiration or combustion. It is absorbed by water, and forms with it liquid fluoric acid. It has a penetrating odour, like that of muriatic acid air, and it corrodes animal and vegetable matters. It emits white fumes in contact with moist atmospheric air. It is very sour, and therefore reddens blue vegetable colors. It unites to other bodies, forming *fluates*, which however have not been much attended to.

BORACIC ACID.

THE last acid, the composition of which is unknown, is called the boracic. It is met with in but small quantities in combination with soda, forming the substance known by the term borax.

This acid may be obtained pure by dissolving borax in hot water, and adding to the solution gradually sulphuric acid, till it be more than saturated. Then evaporate it slowly to one third, and set it aside to cool, when white scales will be deposited, which are boracic acid. To be quite pure, it should be re-dissolved and evaporated again.

This acid appears in brilliant, glittering, white scales, soft and unctuous to the touch. Its taste is slightly sour and bitter. It is soluble in ardent spirit, which it causes to burn, when set on fire, with a green flame. It is difficultly soluble in cold water. When heated strongly, it fuses into glass. It unites to several bodies, forming *borates*, which have not excited much attention.

Besides the acids we have considered, others are procured by the combustion of metals, and some from the vegetable kingdom, which will be treated of when considering metallic and vegetable substances.

DISCOURSE V.

THERE are three substances, which exist in considerable quantities in states of combination and which are called,

ALKALIES.

THEY are remarkable for the following properties: They are incombustible, very soluble in water, and possess an acrid, urinous taste. They unite to the class of bodies called *acids*, and form new compounds, termed *neutral salts*, in which the acid and alkaline properties are lost. They unite to oils, forming *soap*, which is soluble in water. They change various vegetable blues to a green; red to a violet or blue; and yellow to brown. Blue pigments, which have been turned red with acids, are restored by alkalies to their primitive colors. They attract water and carbonic acid from the atmosphere. They corrode animal substances, and if very strong convert wool into a jelly. With these properties, they can be readily distinguished.

The three alkalies are named, AMMONIA, or the volatile alkali; POTASH, or the vegetable alkali; and SODA, or the mineral alkali, which we shall consider in the order in which they are mentioned.

CONCERNING AMMONIA.

THIS alkali exists naturally in the state of air; and was first discovered by Dr. Priestley. It has a very strong and pungent odour. It is lighter than atmospheric air in the proportion of three to five. It extinguishes flame, yet causes the flame of a taper to increase before extinction. It is unfit for respiration. It tinges yellow vegetable colors brown, and blue ones green. It is rapidly absorbed by cold water, then constituting the spirit of hartshorn, or sal-ammoniac, &c. of the shops. It is also absorbed by ardent spirit, essential oils, ether, charcoal and all porous substances. When a piece of ice is brought in contact with this air, it melts and absorbs it, while at the same time its temperature is diminished. When exposed to the temperature of 46°, it crystallizes, and when suddenly cooled down to 68°, it assumes a gelatinous appearance, and has very little odour. It unites to oils, forming *soaps*, called *volatile linaments.* When the electric spark is frequently run through it, while confined over mercury, this air is decomposed into two other airs, nitrogen and hidrogen: 100 parts of it, are separated into 80 parts of nitrogen and 20 of hidrogen, which shew, independently of other experiments, that ammonia is a compound body.

Ammonia may be obtained by several processes.

The common sal-ammoniac is formed of the muriatic acid and ammonia. If to this powdered you add an equal part of quicklime in a glass retort, on applying a moderate heat the ammoniacal air will come over, and should be received over mercury. The common hartshorn of the shops is a solution of ammonia in water; and by means of heat it may be made to part with it. Ammonia is also afforded when tin is added to the diluted nitric acid. The tin in this case attracts the oxigen of the water and acid, and the hidrogen of the water, and the nitrogen of the acid unite, and form ammonia. This air is yielded during the putrefaction of animal matter, and also when they are subjected to the action of a high heat. At one time the formation of the volatile alkali, during the decomposition of matter, was considered as a proof of its *animal* nature; but subsequent experience has taught that this air is afforded by vegetables, and at any time when hidrogen and nitrogen come together in due proportions.

Ammonia unites to the acids, forming neutral salts, which are named according to the acid in combination with the alkali. The acids with which it is most commonly found in combination are the carbonic and muriatic, forming the carbonate and muriate of ammonia.

CARBONATE OF AMMONIA.

—

THIS neutral salt, is commonly called the concrete volatile alkali. It is met with in all apothecary shops. It is very volatile, and is used as a medicine, in doses of from three to eight grains.

This salt is prepared in several ways. For medicinal purposes it may be made by the direct combination of the acid with the alkali; when they unite and adhere to the vessel's sides. It may also be prepared by introducing chalk well dried in a retort with sal-ammoniac, and applying heat. The carbonic acid of the chalk then unites to the ammonia of the sal-ammoniac, forming carbonate of ammonia, which is deposited on the sides of the vessels. The attraction between the acid and alkali is, however, not very strong; for, on adding any of the other acids, they unite to the alkali and the carbonic acid escapes, causing an effervescence. Cold water dissolves its own weight of this salt. One hundred parts of it are found composed of 45 acid, 43 alkali, and 12 of water.

MURIATE OF AMMONIA.

—

THE sal-ammoniac of the shops is a neutral salt, formed by the union of the muriatic acid with ammonia, and is therefore called muriate of ammonia. It may be formed by the direct combination of the acid with the alkali. Most of the sal-ammoniac used in commerce is brought from Egypt, where it is extracted from soot, deposited during the combustion of the excrements of such animals as feed on saline plants. The soot is confined in a vessel half filled with it, and on the application of heat the sal-ammoniac is sublimed. The salt is prepared in other parts, by adding common sea-salt, to a solution of the sulphate of ammoniac. A decomposition ensues. The sulphuric acid unites to the soda, forming Glauber's salts, and the muriatic acid unites to the ammonia, forming sal-ammoniac.

Sal-ammoniac has a penetrating, acrid, urinous taste. In small doses, from ten to fifteen grains, it is given to excite sweating. It is an article much used in the arts, for soldering metals, dying, bleaching, &c. One hundred parts of it are composed of 52 of the acid, 40 of the alkali, and 8 of water.

AMMONIA

Also combines with the other acids, forming neutral salts, which are not of much consequence. The most valuable are the sulphate and the nitrate of ammonia, which may be prepared by the direct combination of the constituents. All the salts formed by the union of acids with ammonia, receive their name from that of the acid and the alkali, as above.

CONCERNING POTASH.

IF vegetable substances be burnt in the open air; if the ashes which remain be repeatedly washed with water, till it becomes tasteless ; and if this water, which is called ley, when strong be then evaporated to dryness, a substance will remain at the bottom of the vessel, known in common by the term pot or pearl ashes. This is potash, or the vegetable alkali in an impure state, in which it is used for the purposes of commerce. The ashes of different kinds of wood yield different quantities of it : Those of the resinous kind, as pine, yielding least. Wormwood, fumitary, stalks of beans and corn, most of the domestic plants, oak, birch, and hickory trees, afford largest quantities of it, when burnt to ashes. Of the last trees, it is said to take 1800lb. to form 100 of ashes, which yield not more than four or five pounds of potash. In the inland countries, where wood is had in abundance, manufactories for separating potash from ashes, on the above principles, are established with great advantage. This article has been occasionally found in an uncombined state in the earth. In combination with the sulphuric, nitric, and muriatic acids, it is frequently met with. Chemists have not yet ascertained, whether potash be separated from the soil in which vegetables grow ; whether it exists uncombined with acids in plants ; whether it be a product of vegetation, or whether it be generated during the process of combustion. At all events, they have not been able to decompose it ; and consequently it is to be considered as an elementary substance.

Potash may be had in a pure state, by dissolving that of the shops in boiling water, to which an equal quantity of quick lime is to be added. The solution is then to be poured off and evaporated. The substance remaining, should be mixed with ardent spirit, and when this settles, the clear liquid is to be poured off and evaporated to dryness in a tin or silver vessel. The heat must not be too intense, or the potash will be evaporated also. In this state it forms the caustic alkali, or common caustic of the shops.

The properties of pure potash are: It has so strong an attraction for water, that it absorbs it from the atmosphere, and thereby becomes fluid. It dissolves all animal parts when brought in contact with them. It liquifies by a gentle heat, and rises in fumes at a high temperature. It unites to sulphur, forming a compound, called *sulphuret of potash*, which is possessed of some remarkable properties. It has a strong attraction for carbonic acid. When fused with an earth called silex, it forms glass. It changes blue vegetable colors green, and finally it possesses all the properties of alkalies.

CARBONATE OF POTASH.

THE carbonic acid unites to potash, and forms the compound called, generally, mild vegetable alkali, salt of tartar, salt of wormwood, &c. but according to the new nomenclature it is termed carbonate of potash. The acid may be united to the alkali directly, by dissolving the potash in water, and causing the carbonic acid to pass through it. This compound was first shewn by Dr. Black to consist of this acid and of the alkali. The attraction of the potash for the alkali is not very strong, as, on adding any of the other acids to it they unite to the alkali, and the carbonic acid escapes, causing an effervescence. Frequently it is administered to patients in this state, of parting with the carbonic acid, when the acid of lemons is added, then constituting what is called, *the effervescing mixture*. The effervescence would be more considerable, if the alkali be fully saturated with the carbonic acid, which, however, is not generally the case.

SULPHATE OF POTASH.

THE acid which has the strongest affinity for potash is, the sulphuric. United to this, it forms the vitriolated tartar of the shops, which should be called, the *sulphate of potash.* It is not much used.

NITRATE OF POTASH;

OR

COMMON NITRE.

POTASH is most generally found in combination with the nitric acid, forming the compound called nitre, or salt petre. It is a salt possessed of very important virtues. It may be formed by the direct combination of the acid with the alkali. But for the purposes of commerce, it is procured from several parts of the world, where it is found blended with the earth, particularly in warm countries. It is made in considerable quantities by mixing animal and vegetable bodies, or ashes, together with a little lime, underneath sheds, where the water does not penetrate, but where the air circulates freely. A contrivance for the purpose should be on every large estate, as it costs but little, and would be very profitable. It has also been procured in considerable quantities, from the ashes of the tobacco plant, and in much larger quantities from grave yards, and old buildings, as in France, Italy and Spain.

In order to ascertain if nitre exits in any substance, it should be well mixed with water, so that the nitre may be dissolved in it. In this solution, bits of paper are to be dipt and dried, afterwards if any nitre have been in the water, when the paper is burnt, it will have a particular sparkling appearance, which indicates the presence of the nitre.

When nitre is found in sufficient quantities with any earth or mixture, to make it an object to extract it, large tubs are procured, in which the substances containing it, are mixed with water. The water dissolves the nitre, and the earthy parts settle at the bottom. If any lime be present, ashes, or potash is usually added. The clear liquor is then to be poured off into wide mouth vessels and evaporated, when the saltpetre will be found at the bottom in an impure state. To be freed from its impurities, it should be again dissolved in water and evaporated.

It was formerly shewn, that the nitric acid is composed of nitrogen and oxigen, each of which exist in our atmosphere. Animal substances contain large quantities of nitrogen, and during their decomposition, this nitrogen absorbs oxigen from the air, and forms the nitric acid. The nitric acid then unites to the potash of the vegetables, or to lime, and forms the common nitre, or nitrate of lime. When the nitrate of lime is formed, then potash is added to it, which unites with the acid, and the lime is disengaged. One hundred parts of the saltpetre, are composed of about 40 nitric acid, 50 potash, and 10 of water, of which last, it may be freed by heat. From this, the formation of nitre about grave yards, &c. can no longer appear mysterious.

Nitre, when heated with any combustible substance, quickly accelerates its combustion, by giving up its oxigen. Hence a variety of bodies will burn in closed vessels, if nitre be added. On the facility of parting with its oxigen is founded the use of gunpowder. This compound is usually formed of seventy-five parts of nitre, nine and a half of sulphur, and fifteen and a half of charcoal. The articles are most intimately mixed together in the large way, by wooden pestles and mortars, which are moved by machinery, turned by water. During the process, the powder is occasionally moistened, and when it is finished, it is wetted still more, and pressed through small holes in skin sieves, which give it a granular appearance. The powder is then dried and put away for common use. When it is intended for particular purposes, it is usually *glazed*. This is done simply, by putting it in a kind of cask, which, turning around, breaks off the irregular parts of the grain, and polishes their surfaces.

The excellence of gunpowder depends very much on the purity of the ingredients used, and the manner of using them. The proportion of the ingredients varies in some manufactories. The charcoal commonly employed is obtained from the willow tree, as that is supposed to be best for the purpose. Perhaps experience will teach, that all charcoal is equally good, if purified by making it redhot in close vessels, previous to using it. Would it not be best to free the nitre from its water of crystallization, by moderately heating it? It has uniformly been found of great consequence to have the articles mixed very minutely together; and the strength of the powder is supposed to be lessened, by wetting it too much, in consequence of which, the nitre separates from the sulphur and charcoal, and crystallizes.

The theory to explain the effects of gunpowder, is very simple. When fire is applied to it, the oxigen of the nitric acid of the nitre, unites to the carbon and sulphur, at the same time giving up its heat and light; by which the carbonic and sulphureous acids formed, with the nitrogen of the nitric acid are suddenly rarefied, and by their expansion, cause the effects noticed.

FULMINATING POWDER.

IF to three parts of nitre, you add two of the salt of tartar and one of sulphur, and reduce them to a fine powder, a compound will be formed, possessed of more remarkable powers than gunpowder. It is called *fulminating powder*. If a dram of it be placed in an iron ladle, and be gradually melted, it will, when the heat is a little increased, suddenly explode, with a noise nearly as considerable as that of a cannon, and frequently burst the bottom of the ladle.

Besides, for the above purposes, nitre is applied to other uses. It is given as a medicine to excite sweating, in doses from 5 to 20 grains. It is used for the preparation of the nitric acid, which is an important article of commerce; and it is applied, with good effects, for the preservation of flesh, to which it gives a beautiful red color.

All the other acids unite to potash, forming salts named according to the acid. These have not excited much attention. The most remarkable is that formed by the oxi muriatic acid, forming the *oxi muriate of potash*. This detonates loudly when rubbed in the mortar with sulphur. It has been used for yielding oxigen air; and some have proposed to bleach clothes with it.

SODA;

OR

THE MINERAL ALKALI.

THE last alkali we have to consider, is called *soda*, or the mineral alkali, which, in its properties, greatly resembles potash. It is found in large quantities in nature. United to muriatic acid, it forms salt, which gives the saltish taste to the waters of the ocean. It is found united to the carbonic, sulphuric, and boracic acids, in considerable quantities, and it exists in all plants growing on the sea shore. It appears to be deposited in large impure masses, under the surface of the earth, in various countries from which it is extracted by running waters. It is found after the spontaneous evaporation of the water, mixed with sand in the bottom of lakes in Hungary, Bohemia and Switzerland, Tripoli, Egypt, China and India. It frequently oozes out of walls, and crystallizes on their surface.

Soda has not yet been decomposed, and in consequence, it must be considered like potash, an elementary substance.— The method of obtaining it pure, is precisely the same as that for obtaining potash. For the numerous purposes of commerce, it is usually obtained from the ashes of plants, growing on the shores of the sea.

The properties of soda differ in no great degree from potash. It may however be distinguished from potash.--- It is rather more fusible than potash in the fire. It has not so strong an attraction for the acids. Exposed to the atmosphere, it attracts moisture and carbonic acid, but does not liquify like potash, but only acquires a pasty consistence, and crumbles into powder. Its evaporation in a high heat, its great causticity, solubility, &c. are as those of potash. United to oils, it affords a solid soap, whereas, that formed by potash and oil, is fluid or *soft*. With silicious earth it forms glass, as will hereafter be shewn.

CARBONATE OF SODA.

THE acid with which the *soda* of the shops is united, is the carbonic, forming the *mild mineral alkali*, which is more properly termed the carbonate of soda. It is usually procured by decomposing plants growing on the sea shore. It is found on the surface of the earth, and on the margin of certain lakes which become dry during the summer. It has often the appearance of a rough dusty powder, of a grey color, and alkaline taste. When pure it is white. This salt is chiefly used as a medicine in affections of the kidneys, in doses from three to five grains, repeated two or three times during the day It would be well before exhibiting it to saturate it with carbonic acid by dissolving it in water and causing a stream of the air to pass through it.

COMMON SALT;

OR

MURIATE OF SODA.

THE acid with which soda is found most generally united, is the muriatic, forming the muriate of soda, called also, common salt, sea salt, and culinary salt. This compound exists in immense quantities in nature. It is diffused throughout the waters of the ocean. Many mineral springs containing it are found in various parts of the world. And there are in several countries mountains and immense mines formed entirely of this article. In Louisania great quantities of it are found forming a mountain. In Switzerland, Hungary and Tyrol it is met with in abundance, as well as in Poland, where it is said the richest mines exist. Near Cardova in Spain, there is said to be a mountain of common salt 500 feet high, and nearly three miles in circumference. When obtained from the earth, it is called *rock salt.* Rock salt is hard, sometimes transparent, and at others, colored from the presence of iron. It is dug out of the mines, pulverised, and sold with great advantage for table use, in small baskets. The chief part, however, of salt used, is obtained from the water of the sea, and is called sea salt, or marine salt. Sea salt is obtained from the water containing it, in various ways.

1. In some parts, the salt sands of the sea coast are washed with the least quantity of water, which is afterwards evaporated.

2. In extremely cold countries, the salt water is allowed to freeze, the ice is then removed, and the remaining water is evaporated.

3. At the salt springs in some places, the water is pumped up and suffered to fall upon heaps of thorns, which divide it and cause a part to evaporate. The further evaporation is carried on by boilers.

4. In southern countries, the extraction is begun by separating a certain quantity of water from the general mass of the sea, which is suffered to remain in square spaces and allowed to evaporate. In most parts, however, the water is put at once in large boilers, and boiled away.

Salt has an agreeable, penetrating, but not bitter taste. It is soluble in rather less than three times its weight of water at a temperature of 70°. One hundred grains of it are composed of 34 muriatic acid, 50 of soda, and 16 of water, of which last it may be freed by heat. The salt, in a strong heat, may be evaporated entirely without decomposition.

Every one knows that large quantities of salt, resist and prevent the putrefaction of animal and some vegetable bodies. A small quantity of it is found, however, to increase putrefaction. The manner by which it operates in such instances is not known.

From the great demand for soda, in the manufactories of soap and glass, its price has become considerable. In consequence of this, it has become an object to separate the soda from the muriatic acid. Various methods have been proposed, but they are not sufficiently economical to justify their adoption, on an extensive scale. In England, however, Mr. Turner extracts the alkali, by means of litharge, which is an oxid of lead, with advantage. His method is to mix the litharge with the salt, so as to form a paste. The litharge gradually unites to the muriatic acid and becomes of a white color. The soda is then washed out with water. Another method is to pour the nitric acid on the salt, which unites to the soda, forming nitrate of soda, when the muriatic acid is disengaged. This nitrate of soda is then mixed with charcoal and burnt, when the nitric acid is decomposed, leaving the soda behind.

NITRATE OF SODA.

THE nitrate of soda has also been called cubic nitre. It is a salt not of much value. It may be distinguished from common nitre, by its burning on coals with a yellow flame, whereas the flame of the other is white.

GLAUBER'S SALTS;

OR

SULPHATE OF SODA.

SODA, united to the sulphuric acid, forms the well known salt, called purging salts, Glauber's salts, &c. by the common people, but more properly, *sulphate of soda*, by chemists This salt may be formed by the direct combination of the acid with the alkali : but it is, in general, prepared by pouring the sulphuric acid on common salt, and applying a gentle heat. The sulphuric acid unites to the soda of the salt, forming Glauber's salts, or sulphate of soda, while the muriatic acid is disengaged in the form of air, is absorbed by water, and is used for other purposes. This salt is found in Austria, Hungary, Switzerland and Siberia, always in the neighborhood of a mineral spring. It occurs usually in the state of a powder of a greyish or yellow white appearance.

One hundred parts of this neutral salt are composed of 14 acid, 22 alkali, and 64 water. When it is left exposed to the air, it parts with this water of crystallization, and appears as a white powder. It has a bitter taste, and one part is soluble in two of water. It swells up on heated coals, and appears to boils from the dissipation of its water. It is used as a purgative, in doses of from one to three ounces; but after it has parted with its water of crystallization, half the quantity is sufficient. In order to render it agreeable to patients, it should be dissolved in cold water with lemon acid and brown sugar.

PHOSPHATE OF SODA.

—

SODA also unites to the phosphoric acid, forming the neutral salt, called phosphate of soda, which is an agreeable cathartic, that has not long since been introduced. It is given in doses from 1 to 2 ounces, dissolved in soup.

This salt may be prepared by the direct combination of its constituent parts. But for the shops, it is prepared by adding the carbonate of soda to a solution of the phosphate of lime, obtained by decomposing burnt bones with sulphuric acid. The phosphoric acid then unites to the soda, and is dissolved in the water, while the carbonic acid unites to the lime, forming chalk which is insoluble.

BORAX;

OR

BORATE OF SODA.

SODA unites to the boracic acid, forming borax or borate of soda, a compound which is brought from India, where it is procured from the bottom of lakes. Generally it is met with in an impure state. It may be purified by dissolving it in boiled water once or twice, then evaporating the water. When pure, it is white, transparent, and has a greasy appearance when broken. Formerly it was much used in medicine, particularly for children with sore mouths, but at present it is much neglected.

When borax is heated it swells up; the water of crystallization flies off, and the salt becomes a porous, light and opaque mass, called calcined borax. If this be exposed to a strong heat, it is melted into a transparent glass, of a greenish yellow color, and soluble in water.

Borax is used, in several of the arts connected with the metals. It is very generally employed in soldering them.

Soda unites to all the rest of the acids, forming neutral salts of no great importance. They are to be named according to the name of the acid uniting to the alkali.

CONCERNING SOAP.

IT has been stated, as one of the properties of the alkalies, that they unite to oils, forming *soap*, an article universally known and used.

SOAP OF AMMONIA;

OR

VOLATILE LINAMENT.

THE volatile alkali, when fully combined with water, so as to form the spirit of hartshorn of the shops, is capable of uniting to the oils, and forming a kind of soap. The combination may be effected, by adding the strong spirits of hartshorn, to olive oil in an equal quantity, and agitating it very well. This is an article chiefly used in applications to joints affected with rheumatism, &c.

SOAP OF SODA;

OR

HARD SOAP.

THE hard soap of commerce is made by the union of fat or oil with soda. The method of making it in the manufactories is as follows:

A quantity of the soda of commerce, is pounded and mixed in a wooden vessel, with about a fifth part of its weight of lime, which has been slacked just before, and passed through a sieve. Upon this mixture a quantity of water is poured, more than enough to cover it; and in this state it is to remain for several hours. The lime attracts the carbonic acid from the soda, and the water becomes strongly impregnated with the pure alkali. This water is then drawn off by means of a stop cock, and it is called the *first ley*. Another quantity of water is then to be poured on the soda, which, after standing two or three hours, is to be drawn off, and called the *second ley*.--- And a third portion of water is then added, and drawn off, and called the *third ley*.

A quantity of oil, equal to six times the weight of the soda used, is then to be put into the boiler, with a portion of the *third ley*, and the mixture must be kept constantly boiling and agitated by means of a wooden instrument. The whole of the third and then the *second ley* must be added at intervals to the mixture. The oil becomes milky, combines with the alkali, and after some hours, it begins to acquire consistence. A little of the *first ley* is then to be added, not neglecting constantly to agitate the mixture. Portions of the first ley are to be added at intervals; the soapy substance acquires gradually greater consistence, and at last it begins to separate from the watery part of the mixture. A quantity of common salt is then to be added, which renders the separation much more complete. The boiling is to be continued, still for two hours, and then the fire must be withdrawn, and the liquor no longer agitated. After some hours rest, the soap completely separates from the watery part, and swims upon the surface of the liquor. The watery part is then to be drawn off and preserved, as it contains some of the soda. The fire is then to be kindled again, and a little *weak ley* to be added to it, to facilitate its melting. As soon as it boils, the remainder of the first ley is to be added to it at intervals. When the soap has been brought to the proper consistence, which is judged of by taking out small portions of it to cool, it is to be withdrawn from the fire and the watery part separated as before. It is then to be heated again, and a little water mixed with it, that it may form a proper paste. After this, let it be poured into the vessels, proper for cooling it, in the bottom of which there should be a little chalk to keep it from adhering. In a few day the soap will have acquired sufficient consistence to be taken out and formed into cakes.

The use of the common salt in the above process is, to separate the water from the soap, for salt has a stronger affinity for water than soap.

Olive oil has been found to answer best for making soap, and next to it tallow may be placed. Other oils have been employed, but not with much advantage. Whale and linseed oil will only answer for soft soap.

Manufacturers have employed various means to increase the weight of soap, without increasing its value. The most common substance used for this purpose is water, which may be added in considerable quantities, especially to soap made with tallow, without diminishing its consistence. This fraud may be easily detected by exposing the soap for sometime to the air, when the water will evaporate and the weight be lessened accordingly. The manufacturers to prevent this evaporation, keep it in a strong solution of sea-salt. Various other methods have also been fallen on to adulterate soap, some of which have not been detected.

Different chemists have analyzed soap, and it is stated to be composed of 60 parts of oil, 10 alkali and 30 of water. Soap made with tallow and soda has a white color and is therefore called *white soap;* but it is usual for soap makers to lower the price of the article, by mixing a quantity of resin with the tallow, which forms the common *yellow* soap. To make the soap *marbled* they add copperas, cinnabar, &c. to it before it is made into cakes.

SOAP OF POTASH;

OR

SOFT SOAP.

—

POTASH may be substituted for soda in making soap, and the process is the same; but the soap has always a soft appearance; it never being more consistent than hog's lard. Its properties do not differ very materially from those of hard soap.

Some have affirmed that they have a method of making hard soap with potash. Their method is this: after forming the soap in the manner above described, they add to it a large quantity of common salt, boil it for some time, and the soap becomes solid when cooled in the usual way. But it should be observed that the soap thus formed contains soda; for when the salt is added (muriate of soda) the muriatic acid unites to the potash and the soda to the oil, which forms hard soap.

SOAP OF WOOL.

—

CHAPTAL has lately proposed to substitute wool, in place of oil in the manufacture of soap. The ley is formed in the usual manner, and made boiling hot, and threads of woollen cloth of any kind are gradually thrown in, where they become soon dissolved. New portions are to be added sparingly, and the mixture should be constantly agitated. When no more cloth can be dissolved the soap is made. It has been used in France with great success; and no doubt, it would be well worth while to save all old woollen rags for the purpose.

The properties of different soaps are found to vary but very little, although there be great differences in the oils of which they are formed. They are all soluble in water and ardent spirit; and may very readily be decomposed by adding acids to them. They are capable of combining with a larger quantity of oil, and rendering it soluble in water. Hence their property of cleansing cloths, linens, &c. When decomposed by a strong heat, they emit the volatile alkali. Several of the neutral salts, contained in the common waters, decompose soap, and the oil rises on the surface in the form of flakes. Such waters are generally called by the washing women, *hard waters.*

The foam or froth which rises on pure water, when agitated with soap, is nothing more than atmospheric air, which by the agitation is thrown in the mixture; and which is retained in it in consequence of the little thin coverings, or *vessels of water* (vesiculæ) which continue long, as they are of a slimy or mucilaginous nature.

Having spoken of soaps, formed with oils, the present is a proper place to mention another kind of soap which has been formed, by the combination of oil with lime. To form this, it is only necessary to agitate lime water and olive oil together. This soap has been applied to *burns*, *ulcers*, &c. with great advantage; but not for the purposes of washing. However, as it appears that lime has the property of uniting to oil, to form a soap soluble in water, it is very probable that lime water, which can readily be made by agitating a little lime in common water, would be a very excellent substitute for soap in the washing of clothes.

The clothes might first be washed in the lime water, which would unite to and dissolve their oil; and then, to prevent the lime from injuring them, they could be soon after agitated in pure water---at least, the experiment seems worth trying.

DISCOURSE VI.

WE come now to treat of a number of elementary bodies, very little resembling those we have considered. They are the substances forming the solid parts of the globe, which have not been heretofore mentioned. They are universally known by the term minerals. They exist in innumerable states of combination. The art of distinguishing them from each other, and the method of describing them with accuracy and precision, is called

MINERALOGY.

THOUGH there seems to be an almost infinite variety of bodies, scattered on the surface of this globe; yet, when they are chemically examined, we find, not without surprise, that they are all composed of a few simple elementary substances, into which every one of them can be reduced by art. These elements in certain properties are found to differ considerably from each other, which has given rise to the distinction between *earths* and *metals*. In this discourse our attention will he confined to the earths, including what are vulgarly called earths and stones, which chiefly differ from each other in cohesion.

The general properties which distinguish *earths*, are as follows: They are incombustible and infusible. They are very sparingly soluble in water and ardent spirit. When perfectly pure they assume the form of a white powder, and are harsh to the touch. They are capable of combining with acids and forming neutral salts. They are also capable of uniting with each other, and with soda and potash. Their weight is less than that of metals, for their specific gravity never exceeds 4 : 9.

Chemists have reduced the number of bodies, distinguished by the above properties of earth, to nine. These they cannot further decompose; and therefore, they are to be considered as *elementary* bodies. Their names are as follows:

1 Silex,
2 Alumine,
3 Lime,
4 Magnesia,
5 Barytes,
6 Strontites,
7 Zircone,
8 Glucine,
9 Yttria.

These will be considered in the order in which they are mentioned, and only that attention will be paid to each, to which it is entitled, by its known importance.

I. SILEX.

SILEX, or silicious earth, is the principal constituent part of a very great number of the compound earths and stones, forming immense masses on our globe. It is the basis of most of the stones which emit light when struck in the dark, as *flint*, quarts, rock crystal, jasper, Egyptian pebble, &c. The sand of the sea shore and rivers, chiefly, also, consist of this earth. The prodigious rocks which are distinguished by the name of *Grantie*, are chiefly composed of this earth. All the various soils of our globe, contain it in larger or smaller quantities. It acts an important part in forming proper situations for vegetable bodies to grow. It is deposited in vegetable substances, forming petrified wood; and is precipitated from the waters of some springs. It is never met with in a perfectly pure state in nature.

Silex may be obtained in a state of purity, by the following process: Reduce to a very fine powder four parts of rock crystal, and add to it one part of potash. Then melt the whole in a strong heat. The mass is to be dissolved in water, and sulphuric acid poured on it, while a white powder falls to the bottom. This powder is to be taken out, washed and dried, and it then constitutes pure silex. This earth may also be had in a state of purity, by introducing the stones containing it in the fluoric acid air. The silex is dissolved by the acid, and when the acid is mixed with water, the earth falls to the bottom.

Silex, when perfectly pure, exists in the form of a white powder. It is insipid and inodorous. It is rough to the touch, cuts glass, and scratches, or wears away metals. Its specific gravity is about 2.66. It is not altered by the combustible bodies; nor does it form a cohesive mass with water. No acid acts upon it, excepting the fluoric. It is unchanged in the air. It has been considered as insoluble in water; but it appears, when in a state of extreme division, to be soluble in ten thousand parts. Its most remarkable, property is, its fusing with soda and potash, in a high heat forming the compound

GLASS.

The method of making glass has not long since been brought to its present state of perfection. The formation of this compound depends entirely on the chemical union of potash or soda, with silicious earth, which takes place in a high temperature. These are not employed alone in a state of purity in the glass manufactories. The purity, however, of the glass, depends very much on the purity of those articles. Hence the variety in the kinds of glass sold in the markets.

Soda and potash are indiscriminately used in the state in which they are met with in commerce, but soda is said to be preferable. Rock crystal is employed in a pulverised state when the finest glass is to be made; but fine white sand, freed from impurities by washing, answers generally pretty well. The articles are to be blended together, in the proportion of one part of alkali and two of sand, and in proper vessels are to be submitted to a strong heat. They then partially melt, part with some of their impurities which rise on the surface, and then constitute what is called *frit*. This frit, while hot, is introduced into other vessels, and exposed to a strong heat until melted, during which time the impurities arising on the surface are to be removed. When the fusion is continued for a proper time, the glass is allowed to cool a little, and is then moulded according to the desire of the workmen. They take a part of the melted matter at the end of a long hollow tube, which is dipped into it, and turned about until a sufficient quantity is taken up, the workman at each turn rolling it gently upon a piece of iron, to unite it more intimately. The tube is then blown through till the melted mass at the extremity swells like a bubble, after which he rolls it again on a smooth surface to polish it, and repeats the blowing until the glass is brought to the necessary size.

If it be a common bottle, the melted matter at the end of the tube is put into a mould of the exact size and shape of its body, and the neck is formed on the outside, by drawing out the ductile glass. If it be a vessel with a large orifice, the melted glass is widened with an iron tool. Should a handle, feet, or any thing of the kind be required, they are made separately, and stuck on at the melted side. Window glass is made in a similar way, except that the bulb at the end of the tube is cut with shears longitudinally, and is gradually bent back until it becomes a flat plate. Large plate glass for looking glasses, &c. is made by suffering the melted mass to flow upon a casting table, with iron ledges to confine it, and as it cools, a metallic roller is passed over it to reduce it to an uniform thickness.

The principal kinds of glass manufactured are called *flint glass*, *crown glass* and *bottle glass*.

Flint glass is the densest, most transparent, colorless and beautiful: in consequence of which it is called *crystal*. The best kind is said to be made of 120 parts of pure white sand, 40 parts, pearl-ash, 35 red oxid of lead, 13 of common nitre, and 25 of black manganese. This is the most fusible glass. It is used for the best utensils and ornamental purposes.

Crown glass differs from the above in containing no lead. It is made of soda and fine sand, and is used for panes of windows, &c.

Bottle glass is the coarsest of all, is least fusible, and is made of soda and common sand. Its green color is owing to iron.

Glass is often colored by mixing with it, while in a fluid state, various metallic oxides. It is colored blue, by the oxid of cobalt; red, by the oxid of gold; green, by the oxid of copper or iron; yellow by the oxid of silver or antimony and violet by the oxid of manganese.

The properties of glass are well known. Its specific gravity varies from 2, 3, to 4, according to the quantity of metal mixed with it. Though brittle when cold, it is one of the most ductile bodies known, it being practicable to draw it out in the finest threads. It is one of the most elastic and sonorous bodies. Fluoric acid dissolves it at common temperatures, and soda and potash at high temperatures.

Glass utensils, unless very small and thin, require to be gradually cooled in an oven. This operation is called *annealing*, and is indispensably necessary to prevent their cracking, by change of temperature, or rough usage.

II. ALUMINE.

THIS earth derives its name from alum, of which it forms the base. It constitutes the lower parts of mountains and plains. All the varieties of clay, owe their properties to this earth. It is met with in various states of combination, with silicious earth, carbonic and sulphuric acids; united to a small portion of silicious earth, it forms a bed for the growth of most of the vegetable bodies. It is the constituent part of many rocks.

It enters into composition with all those stones called *argillaceous*, as *potter's clay*, fuller's earth, mica, adamantine spar, noted for its great hardness, slates, &c. From this it must at once appear a very important earth.

Alumine may be obtained tolerably pure by dissolving alum in five or six times its weight of boiling water, and then adding to it the liquid ammonia of the shops, so long as a white powder is precipitated. This white powder is to have the fluid poured off from it, and then repeatedly washed, and finally dried.

The properties of pure alumine are as follows: it is insipid, adheres to the tongue and occasions the sensation of dryness in the mouth. When moistened with water it forms a soft paste. When heated to redness it shrinks considerably in bulk, and at last becomes so hard as to strike fire with flint. After being heated, it is no longer capable of forming with water a paste; this property, however, it recovers by solution in an acid and precipitation. It possesses a powerful attraction for lime. The most intense heats cannot melt it, except when united with lime and then it is very fusible. It unites strongly to all the acids, forming neutral salts. Its specific gravity is 2. It absorbs carbonic acid and water from the atmosphere. Its attraction for water is so strong, that a lump of it in the common state, in which it contains much of this fluid, will unite to more than twice its weight of it, without allowing any to drop out. In a freezing cold it contracts much and parts with its water, which appears in the form of frost. Hence the frequency of frost in clay soils. Hence the reason why such soils yield large quantities of water for plants. When this earth is exposed to heat, it contracts in proportion to the degree of heat, which arises from its loss of water. It is in consequence of this that Mr. Wedgewood's thermometer indicates the degree of heat, as before observed. This earth is much employed in the arts.

It has been observed that alumine unites to the acids, and forms neutral salts. These salts are to be named according to the name of the acid uniting to the alumine. They may be formed by the direct combination of the acids with the earth. They have not excited much attention, excepting only that formed by the combination of the sulphuric acid with the earth. This is in common language called

ALUM,

But in consequence of its composition it is termed by the chemists, sulphate of alumine. This neutral salt is well known among artists. It may be formed by the direct combination of the sulphuric acid with the aluminous earth. But it is generally prepared for the purposes of commerce, from a combination of sulphur and alumine, which is found in different parts. This compound is heated in a moist air, when the sulphur unites to oxigen forming the sulphuric acid, which unites to the alumine forming sulphate of alumine or alum. Water is then to be poured over the mixture, which dissolves the alum and carries it off. This fluid is then to be evaporated, after a little potash or urine, containing ammonia is added to hasten the crystallization, which then takes place in large transparent masses. Its taste is rather sweet, and very astringent. It contains a good deal of water of crystallization, of which it may be freed by heating it. It then constitutes what is called *burnt alum*, which is sometimes applied to sores. Alum is soluble in two parts of boiling and 15 of cold water. It is used as a medicine in small doses, and is particularly useful in sores of the mouth and throat. It is very extensively used in the arts.

STONE WARE.

POTTERY or stone ware of all sorts, from the coarsest brown pitcher to the finest porcelain, is made of aluminous and silicious earths. The use of the silex is to give strength to the ware, so that it may preserve its solidity during baking. When good ware is to be made, care is taken only to employ the fine parts of the alumine and *chert*, which is a species of flint. With this view the alumine is well mixed in water, by which the fine parts are suspended in the fluid, while the coarse subside to the bottom. The thick liquid is further purified by passing it through sieves. After this the liquid is mixed in various proportions for different wares, with another liquor of about the same consistence, consisting of finely ground flints. The mixture is then dried in a kiln, and after being beaten to a proper consistence, it becomes fit for being formed at the wheel into dishes, plates, bowls, &c. When the ware has been exposed to heat for a certain time it is *glazed*, or is made to undergo a partial vitrification at the surface, without which water would pass through it. Common pottery is glazed with an oxid of lead, or by throwing common salt over it in the furnace.

The yellow or queen's ware is made of the same substances as the common flint ware, but in different proportions. The glazing is also different. It is made by mixing together in water, to a consistence of cream, 112 parts of lead, 24 ground flint, and 6 of flint glass. The ware, before it is glazed, is baked in the fire; by which it acquires the property of strongly imbibing moisture. It is in this state, quickly to be dipped in the composition and taken out, when it is exposed a second time to the fire, in consequence of which, the glaze it imbibed is melted, and a thin gloss is formed on its surface, which is more or less yellow, according to the greater or lesser proportion of lead used.

Porcelain or china, is a semi-vitrified earthen ware of an intermediate nature between common wares and glass. Chinese porcelain is said to be composed of two ingredients, one of which is a hard stone, called *petunze*, which is carefully ground to a fine powder; and the other, called *kaolin*, is a white earthy substance, which they intimately mix with the ground stone.

BRICKS.

THE manufacture of bricks and tyles is a species of this art. To make good articles of this kind, the clay should be dug out of the earth; exposed for some time to the action of the air, and then powdered and made into a paste with water. This paste is to be pressed in moulds; taken out and dried in the sun, and then burnt in a large kiln made for the purpose. This kiln had best be lined with a mortar of charcoal and clay, which will retain the heat to act on the contents of the kiln.

The qualities of bricks, &c. depend on the nature of the clay used and the intensity of the heat to which they have been exposed. Common clays are composed chiefly of silex and alumine in various proportions. When the alumine abounds, the brick contracts much and is apt to crack while burning. This inconvenience is remedied by adding sand to the clay. It has been found that a little lime will render the bricks more fusible; and for the purpose of favoring their vitrification, it is sometimes used with advantage. It is the oxid of iron which gives to the bricks their color.

As lime disposes clay to fuse or melt, it is necessary to avoid using it in the construction of vessels exposed to high heats.

III. LIME.

THIS earth is commonly known by the term calcareous earth. It is found in immense quantities in nature, though never in a pure state. It is always combined with an acid. With the carbonic acid it forms chalk, common lime-stone, marble, calcareous spar, &c. It is contained in the waters of the ocean; it is found in vegetables, and it is the basis of the bones, shells, and other hard parts of animals. Its combination with the sulphuric acid, forms sulphate of lime or *gypsum*, or plaster of Paris. United to the fluoric acid it constitutes fluate of lime, or Derbyshire spar.

Lime may be obtained in a pure state from good chalk, marble, or oyster shell powder. For this purpose nothing more is necessary than to expose it to a high heat in a furnace, when it parts with its carbonic acid, and the lime remains pure. It is on the same principle, that lime-stone, shells, &c. are burnt in common: they part with carbonic acid in the high heat, and the lime consequently is left pure. In some instances, the limestone contains impurities, particularly silex which cause it to melt in the kilns; and this is called over burnt lime.

When lime is pure, its properties are as follow: It exists in a solid mass of a white color, moderately hard, but easily reducible to powder. Its taste is bitter, urinous and burning. It changes blue cabbage juice to a green: it cannot be fused alone in furnaces; it crumbles into powder in the air; loses its strong taste, absorbs water, and is increased in bulk. Its specific gravity is 2, 3. Its slacking by water is attended by the extrication of heat; by hissing, splitting and swelling up, while the water is partly consolidated and partly converted into vapor, and the lime is reduced to a dry powder. It acts as a caustic on animal matter. It unites to all the acids forming compounds possessed of various properties, which are named according to the name of the acids. It is soluble in 300 times its weight of water.

The lime water of the shops is nothing but lime dissolved in water. To make it, nothing more is necessary than to add a handful of slacked lime to hot water, and agitate the mixture. In an hour or so, it is fit for use, and it may be poured off in bottles which are tightly stopt. This article is used by physicians, in cases of indigestion; by chemists, to detect the presence of several substances, and by artists to make good mortar.

CHALK;

OR

CARBONATE OF LIME.

IF lime water be left uncovered, a white crust forms at the top. This is common chalk, which is insoluble in water. It is formed in consequence of the union of the carbonic acid of the air with the lime, and in the new nomenclature it is consequently termed the *carbonate of lime*. The attraction between the acid and the earth is, however, so inconsiderable, that on applying any of the acids of the shops, they unite to the earth, and the carbonic acid is disengaged, so as to cause an effervescence.

Chalk, or carbonate of lime, exists in immense quantities in nature; no other mineral can be compared with it in the abundance with which it is scattered over the earth. Many mountains consist of it entirely, and hardly a country is to be found on the face of the globe, where it does not constitute a greater or lesser part of the riches of the mineral kingdom. But, perhaps, it is seldom or never found in an entirely pure state. The variety of substances with which it is occasionally found united, has given rise to several distinctions, which are grounded on appearances; of these it will be necessary to notice the most remarkable.

Common white chalk is found mixed with saline substances, iron and stones of different kinds. It may be freed of most of its impurities, by powdering and washing it very well. The soluble parts are carried off by the water, and the chalk remains behind. When this is made into little lumps, it is called *prepared chalk*. It is much used in medicine in large doses, particularly in billious fevers.

Calcareous spar, formed in the tops of caverns, and deposited from the water passing through them, is a combination of lime and carbonic acid, with a little water, which enters into its composition. The various kinds of marble have nearly the same ingredients. This is found in immense quantities in the earth in various places. It differs in density, hardness, weight and color, and from the closeness of its texture, it can receive a very fine polish. White marble is almost a pure carbonate of lime. The other kinds contain silex, alumine, and iron; to which last, they frequently owe their color. By insensible gradations, marble passes into lime stone; which is of a coarser texture, is more brittle, has less lustre, and contains greater impurities. Marl is the last variety of this earth which I shall name. It exists in the form of a yellowish grey mass, crumbles on exposure to air, and in water falls into powder without forming a paste. This contains most impurities.

All the above species of carbonate of lime, will in high heats part with their carbonic acid. The quantity they part with can be ascertained by heating them in a retort, connected to a pneumatic tub, and receiving the air. One hundred parts of these will be found to contain, generally about 40 parts carbonic acid and 50 of lime.

PLASTER OF PARIS;

OR

SULPHATE OF LIME.

THE sulphuric acid unites to lime, forming the well known substance, called *plaster of Paris*, gypsum, selenite, or more properly termed sulphate of lime. It is found in great quantities in nature, existing in immense masses, and also diffused through various soils and waters. In masses it is met with in various states either in a powdery form, or state of hardness, forming varieties either white, grey, yellow, green, or red. Sometimes they contain chalk, which may be detected by adding a strong acid, which will disengage the carbonic acid. When good it is composed of about 35 parts lime, 45 sulphuric acid, and 20 parts water.

Plaster of Paris is soluble in 500 times its weight of water, at a temperature of 60°. Exposed to heat it appears to boil or effervesce, in consequence of the extrication of the water it contains; afterwards it becomes opaque and falls into a white powder. This powder, when mixed with water absorbs it rapidly, and though of the consistence of cream, it becomes soon solid by a kind of crystallization. In consequence of this, it is frequently put in moulds made in fanciful shapes, the forms of which it acquires and retains, so that they serve for ornaments.--- This is called plaster or *stucco work*. This compound has been lately extensively used as a manure, particularly in the cultivation of clover with great success. The industrious and respectable Mr. Binns, of Loudon county, Virginia, has published some interesting facts concerning on its use as a manure in a small pamphlet.

NITRATE OF LIME.

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THIS compound, as its name indicates, is composed of the nitric acid and lime. It is found in great quantities about old buildings, and is used chiefly as a manure, and to separate the nitric acid from it. This is done by simply adding potash to it, which unites to the acid forming nitre, which is dissolved in water.

MURIATE OF LIME.

—

THE muriatic acid unites to lime, forming a neutral salt, which has been employed to create most intense coldness, by mixing it with snow. If a saturated solution of it in water, be added to a saturated solution of the carbonate of potash in the same fluid, the two instantly become solid, because the carbonic acid unites to the lime and the muriatic acid to the potash, and in crystallizing render the water solid.

DERBYSHIRE SPAR,
OR
FLUOR SPAR,
OR
FLUATE OF LIME.

—

THE fluoric acid is found in nature united to lime forming Derbyshire or fluor spar, more properly called *fluate of lime.* It is employed to yield the fluoric acid.--- Greatest quantities of it are met with in England, in the county of Derbyshire: hence its vulgar name.

PHOSPHATE OF LIME.

THE phosphoric acid is found united to lime in nature, forming the fossil called *apotite*, which is generally red, grey, green or purple colored with some lustre. The bones of animals consist chiefly of the phosphate of lime, from which the phosphoric acid is obtained, as stated while considering phosphorus.

Lime is also capable of uniting to all other acids, and forming compounds which should be named according to the acid. These compounds have not exited much attention,

Besides the acids, lime combines chemically with sulphur and phosphorus, forming a sulphuret and phosphuret of lime. The first is said to have the properties of the alkalies. Phosphuret of lime may be made by heating the lime with phosphorus in a tube. This compound decomposes water when introduced in it, and forms phosphorated hidrogen air, which burns on coming in contact with atmospheric air at the lowest temperature. Lime also by fusion unites to alumine, silex, and barytes, and renders these earths very fusible, as has been before observed.

MORTER.

—

LIME forms the principal part of the morter, or cement, used for connecting stones and bricks in buildings. It is generally made of lime, sand, and water. It becomes solid in consequence of a kind of crystallization, and a slow absorption of carbonic acid from the air. No certain proportion of lime, silex, and water, for forming morter, is adhered to in this country. It is, however, stated that the best morter is made of one part lime and two of sand, with as much water as is necessary to give it consistence, which are to be most minutely beaten or mixed together.

Guyton de Morveau states that an excellent morter may be made of the following ingredients, which has the property of hardening under water. Take four parts of blue clay, six of black manganese, and nine of chalk, finely powdered, and expose them to a strong heat. To this sixty parts of sand should then be added, and the whole made into a paste with a sufficient quantity of lime water.

From a late discovery of Dr. Higgens, it has been proved that *burnt bones* has a most happy effect in increasing the virtues of morter. According to the Doctor's direction, 55 parts of washed coarse sand, whose single grains do not exceed one sixteenth part of an inch in diameter, and forty-five of fine sand should be mixed together, and wetted with lime water. To this 14 parts of slaked lime are to be gradually added and well beat together, and lastly, the same quantity of powdered bone ashes. The addition of manganese, it is stated, uniformly gives to morters the property of hardening under water.

IV. MAGNESIA.

MAGNESIA is not found pure in nature, but is obtained by art from some of its combinations. It gives a peculiar character to most of the substances with which it is combined. The stones containing this earth in considerable quantities have generally a smooth and unctuous feel, a greenish cast, a fibrous texture, and a silky lustre. Among them may be mentioned talc, soap rock, serpentine, asbestos, mountain cork, jade or mephitic stone, boracite, &c. This earth is also found united to acids, diffused in sea-water and in some sea plants.

Magnesia may be had in a state of purity from the water left after the extraction of salt from sea-water. To this water the substance called copperas, which is composed of sulphuric acid and iron, is to be added. The sulphuric acid unites to the magnesia, forming Epsom salt, or the sulphate of magnesia, which may be crystallized by evaporating part of the water. This sulphate of magnesia should be again dissolved in water, and the carbonate of soda be added to it, so long as a white powder falls to the bottom. This white powder is the magnesia sold in the shops. It is formed of the carbonic acid and magnesia, and may be freed of the carbonic acid, by heating it in a tight vessel, until it ceases to effervesce, when strong acids are applied to it.

Pure magnesia does not form with water an adhesive paste. It is in the form of a very white spongy powder, soft to the touch, and perfectly tasteless. It is very slightly soluble in water. It absorbs carbonic acid from our atmosphere; changes some blue vegetable colors to green. Its specific gravity is about 2. 3. It is infusible alone, but not so when blended with other earths. When heated strongly, it becomes phosphorescent. It unites to all the acids, forming salts, very soluble, and possessing a bitter taste. Its attraction however for the acids, is not equal to the attraction of the alkalies for them.

CARBONATE OF MAGNESIA.

THE common uncalcined magnesia of the shops, is a pure carbonate of magnesia. It may readily be made to part with the carbonic acid, by adding other acids, or by means of heat. In the last instance it forms what is called calcined magnesia. The Magnesia of the shops is made in considerable quantities, by adding to saturated solutions of Epsom salt, or sulphate of magnesia, the carbonate of soda, when the sulphuric acid unites to the soda, forming Glauber's salts, and the carbonic acid to the magnesia, forming common magnesia. One hundred parts of it are composed of about 50 parts of the earth, 30 of the acid, and 20 of water. It is used chiefly as a laxative for children, and to correct the acidity of the contents of the stomach which cause heart-burn. It is remarkable, that cold dissolves more of this compound than hot water.

EPSOM SALT;

OR

SULPHATE OF MAGNESIA.

THE sulphuric acid unites to magnesia, forming the purgative salt formerly much used, called Epsom salt, or more properly sulphate of magnesia. This salt is made in considerable quantities from Epsom's springs in England, whence its name. It is exceedingly bitter, and is used in doses equal to those of Glauber's salts. It is now chiefly employed for the preparation of magnesia. It differs from Glauber's salts, in not turning into a white powder when exposed to the air. It is composed of 24 parts acid, 20 earth, and 56 water.

MURIATE OF MAGNESIA.

THE muriatic acid unites to magnesia forming a neutral salt, very bitter, very soluble in water, and which exists in sea water, and is the cause of its bitter taste.

All the rest of the acids unite to magnesia, and form compounds, wich have not been found of consequence.

V. BARYTES.

THIS earth exists in nature in combination, and comparatively speaking, but in a small quantity. It was first obtained from a body called *heavy spar*, which is found about mines. This heavy spar is composed of the sulphuric acid and the earth barytes. The earth may be obtained from it in a state of purity, by pulverising it and boiling it in a solution of the carbonate of potash, in a Florence flask for two hours. The solution is then to be filtered, and exposed to a strong heat in a retort.

Pure barytes has a stronger affinity for the sulphuric acid, than it has for any other body; and consequently it serves to detect the presence of the acid. For this purpose it is employed in combination with the muriatic acid, as it parts with the muriatic to unite to the sulphuric acid.

Barytes is infusible alone, but not so, when combined with other earths. Its specific gravity is 4.00. Exposed to the air and moisture, it slakes much more rapidly than lime. It unites to phosphorus, forming a compound which decomposes water more quickly than the phosphuret of lime. It is soluble in 20 times its weight of cold, and twice its weight of hot water. It unites to all the acids, forming compounds, which have not yet been found of great consequence. Its union with the muriatic acid, forms the muriate of barytes, which a few have thought useful in scrofulous affections, in doses from 5 to 50 drops per day. In general it is a very fatal poison to animals.

VI. STRONTITES.

THIS is an earth, discovered lately at Strontian in Scotland, from whence it takes its name. It was for some time confounded with barytes, and indeed it resembles barytes so much in its properties, that what was said of the one will apply to the other. It is found but in small quantities, and united to the sulphuric and carbonic acids. The neutral salts it forms, differ from those of barytes, are less injurious to animals, and have not been found of consequence.

VII. ZIRCONE.

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THIS is a new earth, lately discovered in the Zircon or Jargon, a gem first brought from the island of Ceylon, but also found in Europe. Its color is either grey, greenish, yellowish, redish, brown, or purple.

Zircon is a remarkably heavy earth; its specific gravity being 4. 3. It unites to all the acids, and it has not yet been found of any consequence in the arts.

VIII. GLUCINE.

—

THIS earth also has been but lately discovered in a few gems, such as the emerald of Peru. Its specific gravity is 2.967. It unites to the acids, forming neutral salts, remarkable for a slightly sweet and astringent taste---hence the name of the earth. It is soluble in the alkalies.

IX. YTTRIA.

—

THIS is an earth discovered also not long since. It is the heaviest earth known; its specific gravity being 4.840.

It has been found but in small quantities, and in some of its properties resembles glucine.

Besides the above earths, there are one or two more spoken of by some authors. *Agustine* is a name applied to one earth, which several consider as a distinct earth. No doubt but that many may meet with compounds which they cannot decompose; but before such are ranked among the *elements*, they should be met with by many chemists. It must at once appear, that the only earths found of great consequence, are those first treated of, which are, silex, alumine, lime, magnesia, and barytes.

DISCOURSE VII.

HAVING considered the most striking qualities of the bodies termed *earths*, we proceed to treat of the remaining parts of the globe, which are called metallic bodies, or *metals*. The properties of these metals, differ materially from those of other substances; but they are of not less importance in the creation. Without them, the arts and sciences could never have arrived at their present state of perfection. Such was the value placed on them by the ancients, that those who first acquired the art of working them, were raised to the rank of deities. At one period, chemical researches were confined solely to the metals; and the science has received its existence from the rage to transmute them or convert the common kind, into gold and silver.

Metals are distinguished from all other bodies by remarkable qualities.

1. Their specific gravity is greater than that of other bodies. The heaviest body, not metallic, has not a specific gravity exceeding 4 : 5; while that of the lightest metal is

6.702. This specific gravity is increased by hammering the metals

2. They are more opaque, or resist the passage of light more than other substances.

3. They possess greater *lustre* or brilliancy than other bodies, in consequence of reflecting more light.

4. They are remarkable for *malleability*, a property by which is meant their capability of being hammered into thin plates or leaves.

5. Also, for their *ductility*, by which is meant their capability of being drawn into wires.

6. They are more *fusible*, at least, than earths.

7. Their *hardness* is greater than that of most substances.

8. They are the best conductors of electricity, heat and galvanism.

But these properties, in different metals, are found to differ considerably. For example; mercury is always fluid in a heat above 40° below 0°: while it is only in the highest heat, platina can be fused.

The pure elementary metals are remarkably susceptible of combination. This tendency to combination is so strong, that it is seldom they are found in a pure state. When they are found in a pure state, or only united to each other, they are said to be *native*. When they are found united to sulphur, oxigen, or any other body, they are said to be *mineralized*. They are always found in the bowels of the earth, in which state they are called *ores*. The ores of metals are generally found in mountainous parts, and forming a continued chain, in the crevices of rocks, which are termed by miners *veins*. The metallic matter is commonly mixed with some earth, different from that of the rock, in which the ore is found: this is termed its *matrix*. To obtain the metal, the matrix is separated by pounding, washing, or other mechanical contrivances; or by roasting and then melting them in contact with the fuel. The art of extracting metals is called *metallurgy*.

The metals unite to each other *chemically*, and form compounds called *allays*: This union is usually effected by heat. These allays always possess the metallic properties; but differ considerably in their gravity, hardness, fusibility, &c. from the metals of which they are formed.

The metals are to be considered as *oxidable*, or combustible bodies. They unite to oxigen in various proportions, and with different degrees of rapidity; some doing it very slowly, and others so rapidly, as to *blaze*, or throw out heat and light. If lead, or iron be melted while exposed to this air, it will gradually lose its metallic properties, and appear something like an earth. This is in consequence of its uniting to oxigen. The product was formerly called a calx, but more properly at present an *oxid*. The process is termed *oxidation*. These metallic oxids may be made to give up their oxigen, if heated in close vessels; particularly if in contact with charcoal, and then they re-assume the metallic state. One hundred parts of a few of them contain near 50 parts of oxigen: but most of them contain much smaller quantities. The color of the oxid, varies with the quantity of oxigen it contains.

The metals, after they are reduced to the state of *oxids*, are capable of uniting to the acids, forming neutral salts, which have been called *metallic salts*. *Unless the metals be previously united to oxigen, they cannot combine with the acids.* Some acids, however, when added to metals, part with some oxigen, to oxide them, and then combine with them, forming metallic salts. Some of the metals unite to such large quantities as to form acids, as will hereafter appear.

The difference in the properties of metals has given rise to their classification. Some of them are called, *noble* or *perfect* metals, *imperfect* and *semi-metals*, *brittle* and *malleable* metals, &c. But these divisions are defective and useless. I shall consider them in the order in which they will be enumerated.

Concerning the number of pure, simple, or elementary metals, in nature, authors have not determined. Some state that there are but 20, others 21, 22, and a few 23. Those, however, of which they are doubtful, are of no consequence; as is the case with some which they have described. I shall pursue my plan of devoting to each the attention to which it is entitled from its known virtues.

NAMES OF THE ELEMENTARY METALS.

1 Mercury,
2 Platina,
3 Gold,
4 Silver,
5 Copper,

6 Iron,
7 Tin,
8 Lead,
9 Zinc,
10 Bismuth,
11 Antimony,
12 Arsenic,
13 Manganese,
14 Cobalt,
15 Nickel,
16 Molybdena,
17 Tungsten,
18 Uranium,
19 Titanium,
20 Tellurium,
21 Chrome,
22 Columbrium.

FIRST METAL.

MERCURY.

MERCURY, or quicksilver, is a metal distinguished from all others by its fluidity in a common temperature. It is only at 40° below 0°, that it is solid. It may be volatilized at a temperature of about 500°.

This metal is found in different states in nature. In several parts of the world, it is found mixed with various substances as oxigen, sulphur and silver. United to oxigen it forms the *hepatic ore;* with sulphur, it forms native *ethiops* and *cinnabar*. The ethiops, is of a dark color, without transparency or lustre, and is of a loose consistence. The cinnabar is of a red color, with considerable lustre in masses, which when reduced to a fine powder is sold in commerce under the name *vermillion*, and is much used as a paint. This may be prepared by the direct combination of sulphur with mercury, aided by the application of heat. Combined with silver, it forms the ore called *amalgam of silver*, which is of a silver white or grey. These ores are found in great quantities in South America, Spain, Hungary, and China.

In order to obtain mercury from its ores, it is necessary to employ heat. When the mercury is mixed with sulphur or oxigen, it should be heated in a retort, with one third its weight of the filings of iron, or lime, and on applying heat, the mercury rises and comes over, in the vessel connected to it. When the mercury is united to another metal, it is only then necessary to distil it in a proper vessel.

Mercury in its metallic state unites to various metals, forming important compounds, called *amalgams*, which will hereafter be considered. It may be divided into very small globules. It undergoes slowly an evaporation, when uncovered in common temperatures. It is an excellent conductor of heat, electricity, and galvanism. Its specific gravity is 13.563. Although a fluid, its opacity is equal to that of any other metal. When clear, its surface has considerable lustre and resembles silver. When agitated in the air, especially with thick fluids, it becomes of a black color. At the temperature at which it boils, it absorbs about 15 per cent. of oxigen, and is then changed into a red oxid, which may be freed of its oxigen by heating it in a close vessel. When reduced to the state of an oxid, it is capable of uniting to all the acids, and forming compounds possessing various properties. At one time the shops were crowded with the various preparations of mercury; but as the rage for such a variety has fortunately subsided, only a few are retained, from which every good may be derived. These are called, *red precipitate* or nitrate of mercury, *corrosive sublimate* or oxi-muriate of mercury, and *calomel* or muriate of mercury.

RED PRECIPITATE;

OR

NITRATE OF MERCURY.

THE nitric acid when poured on mercury, parts with a portion of its oxigen, which unites to the mercury forming an oxid; the remaining acid unites to this oxid of mercury and forms the nitrate of mercury or *red precipitate*, which when heated crystallizes into a red mass of a brilliant appearance. This is chiefly used as an application to callous sores.

CORROSIVE SUBLIMATE;

OR

OXI-MURIATE OF MERCURY.

THE corrosive sublimate of the shops is thus formed. In glass vessels the sulphuric acid is boiled on mercury, until the metal is oxided, and then united to the sulphuric acid, forming the sulphate of mercury. To the sulphate of mercury a quantity of dried common salt is to be added. These are to be introduced in glass vessels, and gradually exposed to a strong heat. In this case, the muriatic acid of the salt unites to the oxid of mercury, forming the corrosive sublimate, which sublimes and adheres to the upper part of the vessel. The sulphuric acid unites to the soda, forming Glauber's salts, or sulphate of soda, which remain at the bottom of the vessel. The vessels are to be broken, and the sublimate taken out and pulverised. It then constitutes the corrosive sublimate of the shops, which is applied in weak solutions in water to eruptions, sores, &c. It is soluble in 16 times its weight of water, but in much larger quantities when ardent spirit or sal-ammoniac is added.

CALOMEL;

OR

MURIATE OF MERCURY.

IN order to prepare calomel, it is only necessary to rub together equal parts of corrosive sublimate and pure mercury until the mercury entirely loses its metallic appearance. In this case, the mercury abstracts a part of the oxigen from the corrosive sublimate, which lessens its activity, and converts it into calomel or muriate of mercury. This preparation is quite insoluble in water, and to be purified must be repeatedly washed in water. It is used to excite salivation in small doses; and in doses from 10 to 20 grains it is an admirable cathartic.

SECOND METAL.

—

PLATINA.

THIS is a metal which has only been found in the mines of Peru, intermixed with gold and iron. It is met with in a native state in the form of small grains. When pure, it is of a white color, like silver, but not so bright. Its specific gravity is between 20.6 and 23. so that it is considerably the heaviest body known. It is very ductile, or may be drawn out into very small wires; and is very malleable, or may be hammered into very thin plates. For its fusion it requires a most intense heat, and in fact cannot be at all melted in common furnaces. In high heats, however, it becomes soft, and may be welded together as iron. Since Mr. Hares' use of hidrogen air to generate heat has been suggested, it is probable that large quantities of this metal may be hereafter melted and applied to useful purposes, such as making vessels to resist the action of intense heat. Platina unites to most of the metals forming alloys, most of which, however, have not been attended to. The metal is valued chiefly for its great hardness, infusibility, and not being tarnished on exposure to air.

Platina, it is said in an intense heat, and in oxigen air, unites to oxigen forming an *oxid* of platina, which may be dissolved by the acids. This metal is also oxided in the nitro muriatic acid, formed by the muriatic and nitric acids, and is then dissolved. On adding to this solution the *muriate of ammoniac* the platina is precipitated, by which property the metal may be distinguished from every other one.

THIRD METAL.

—

GOLD.

GOLD is a metal which has long since been known and highly valued. It is found in the metallic state, seldom perfectly pure, but mixed with silver, copper, iron, and arsenic, forming alloys. It is met with in the sands of many rivers, particularly in Africa, Hungary, and France, in small grains called gold dust. The largest piece of native gold ever discovered in Europe, was found in Ireland, its weight being 22 ounces. It has been found united to sulphur in Transylvania. In North Carolina considerable quantities have lately been found in mines, in the metallic state; and the prospects of its proving of great value were so flattering, as to induce the benevolent and enterprizing Dr. Thornton of Washington city, to establish a company for procuring the gold. But the chief part of the gold in circulation has been obtained from the mines of South America.

When gold is found *native*, or in other words, in the metallic state, it exists in small grains, blended with sand and other bodies. In this case the miners place it where a gentle stream of water passes over it, and washes away most of the lighter impurities. It is then put in a mortar and rubbed up with one tenth of mercury, until the two metals unite together. The whole is then put on a table placed in an inclined direction, and the mercury with the gold runs off. It is then put in a retort and strongly heated, when the mercury flies off, and leaves the gold behind.--- Sometimes the gold so obtained, contains silver, of which it may be freed by reducing it to thin plates, and putting it in the nitric acid, which dissolves the silver, but does not act on the gold. The silver may then be procured from the nitric acid by adding to it muriatic acid, which unites to the silver. This muriate of silver is then to be mixed with soda and exposed to a strong heat, when the muriate of soda is formed and the silver remains pure.

When gold is found mixed with sulphur or arsenic, the ore should be *torrefied* or roasted, by which these substances are volatilized. The ore should then be washed and mixed with lead and melted, so that an alloy of gold and lead is formed. This is then to be heated in a vessel called a *cupel*, which is porous, and is made of burnt bones. The lead melts and passes through the *cupel*, while the gold remains pure. Perfectly pure gold may be had by dissolving the gold of commerce in the nitro-muriatic acid and precipitating it by adding a weak solution of the sulphate of iron. The precipitate when washed and dried is pure gold. When it is designed to ascertain if this metal exists in any ore, the ore should be rubbed up with the nitro-muriatic acid, and then a little of a solution on the muriate of tin should be added. If the solution contain any gold, a purple precipitate immediately appears, which is an oxid of gold. If it contain any iron, it will become black on adding a tincture of nut galls. If it contain silver, it may be precipitated by adding a little muriatic acid. And the presence of copper may be detected by keeping a plate of iron in it for some time.

The properties of pure gold are very generally known. It has a rich brilliant yellow color, and is the heaviest body in nature excepting platina. Its specific gravity is 19.3. Its hardness is not very considerable. Its ductility is very great, and its malleability is such, that one grain of it may be made to cover 56,718 square inches. It melts at 32° of Wedgewood, may be volatilized in a higher heat, but is incapable of uniting to the oxigen of the air in any temperature. Electricity and galvanism inflame it, and convert it to a purple oxid, which flies off in the form of smoke. It unites to most of the metals forming different alloys. It is soluble in the sulphuret of soda and potash, and can then be dissolved in water; and by this process it is supposed Moses destroyed the golden calf.

Gold is not oxided by any of the acids, excepting the nitro-muriatic, called also oxi-muriatic acid. After this acid oxides it, the gold is dissolved in it. It may then be precipitated in the state of an oxid, by several substances; as the alkalies, lime, magnesia, tin, &c. When a sheet of tin is added to a solution of gold, the gold is precipitated in the form of a powder, which is called the purple powder of Casius, which is used in coloring porcelain. When it is precipitated by means of ammonia, a powder appears of a yellow color. This is called fulminating gold. It contains a little ammonia; and if washed and dried, when gently heated, it detonates, in consequence of a decomposition of the ammonia and extrication of its nitrogen air. However, the various compounds, formed by the acids and gold, have not been much examined.

The uses to which gold is applied, are generally known. Commonly that used as a coin, is adulterated with silver, copper or platina. From the beauty of its color, it is employed variously for ornaments. When drawn into very fine wire, it is used in embroidery.

CONCERNING GILDING.

BY gilding is meant the art of covering the surfaces of bodies with gold. Some use the term to denote silvering also, but improperly. This application of gold to the surface of other metals, so as to give them its color, is variously effected, as will appear from the following.

SHELL GOLD, OR GOLD POWDER

For *painting*, may be made by uniting one part of gold with eight of mercury, and then evaporating the mercury by means of heat, which leaves the gold in the form of powder, in which state it is applied to the surfaces of bodies.

GILDING BY FRICTION.

LET a fine linen rag be steeped in a solution of gold for some minutes, then let this rag be dried and burnt. When any thing is to be gilt, it must previously be well burnished: a piece of cork is then to be dipped, first into a solution of salt in water, and afterwards, into the black powder. The substance to be gilt, is then to be rubbed with it and burnished. This powder is frequently used for gilding delicate articles of silver.

GILDING OF BRASS OR COPPER.

FINE instruments of brass, in order that their surfaces may be kept clean the longer, may be gilt by immersing them several times in a solution of gold, free from excess of acid, and afterwards they are to be burnished or polished.

WATER GILDING.

THIS term was probably at first confined to such processes as demand the use of a solution of gold in nitro-muriatic acid, and means a chemical application of gold to the surface of metals. If a solution of gold be copiously diluted with ardent spirit, a piece of clean iron will be gilt, by being repeatedly steeped therein. But a much better method is the following: pour into a solution of gold, in nitro-muriatic acid, about twice as much sulphuric ether. In order to gild iron or steel, the metal must be well polished, with the finest emery or red oxid of iron and spirit of wine. The ether which has taken up the gold, is then to be applied with a small brush; it evaporates, and the gold remains on the surface of the metal; the metal may then be put into the fire, and afterwards polished. In this manner, all kinds of figures may be delineated on iron, by employing a pen or small brush. Iron is also gilded by means of heat. For this purpose, the iron must be heated till it has acquired a blue color. When this is done, the first layer of gold leaf is put on, slightly pressed, and exposed to a gentle fire. It is usual to give three or four such layers, and the heating is repeated at each time, and lastly, the work is burnished.

GRECIAN GILDING

Is thus performed: equal parts of sal-ammoniac and corrosive sublimate are dissolved in nitric acid, and in this gold is dissolved. Upon this, the solution is somewhat concentrated, and applied to the surface of silver, which becomes quite black; but on exposure to a red heat, it assumes the appearance of gold.

GILDING COPPER, SILVER OR BRASS;

BY

THE AID OF MERCURY.

FOR this purpose, eight parts of mercury, and one of gold are alloyed, by heating them together. When the gold is all dissolved, the mixture is put into cold water, and is then fit for use.

Before the alloy is laid upon the surface of the metal, this last is brushed over with diluted nitric acid, in which it is of advantage, that some mercury may have been dissolved. The alloy must then be laid on as uniformly as possible, and spread very even with a brass or wire brush, wetted from time to time with water. The piece is then exposed to heat, which drives off the mercury and leaves the gold behind. Its defects, if any appear, are to be remedied by the application of more of the alloy. The whole is then polished or rubbed over with gilders' wax; which is made of one ounce of verdigris and copperas, with four ounces of bees wax; and the last is to be burnt by exposure to heat.

PAINTING WITH GOLD UPON PORCELAIN OR GLASS,

Is done with the powder of gold, which remains behind after driving off the nitro-muriatic acid, from a solution of that metal. It is laid on with borax and gum water or oil burned in and polished.

THE GILDING OF GLASS

Is commonly effected by covering a part with a solution of borax; and applying gold leaf upon it, which is afterwards fixed by burning.

THE EDGES OF TEA CUPS, &c.

Are frequently gilt in a less durable manner by applying a very thin coat of amber varnish, upon which gold leaf is to be fixed, and when the varnish dries the gold is burnished.

The gilders of wood and other compositions, designed to supply the place of carved work, make use of gold leaf, which is either laid on with size or boiled oil, and afterwards burnished.

FOURTH METAL.

SILVER.

THIS metal is familiar to every one. It is found in the metallic state, united to lead, antimony, copper, mercury, and arsenic; and it is found mineralized with sulphur and the arsenic acid. The mines yielding most silver, are in South America, Germany, Norway and France.

Silver is obtained from its ores in different ways. In Peru and Mexico, the mineral is pounded, roasted and washed, and then rubbed up with mercury in vessels containing water. The mercury and silver unite forming an alloy, which is afterwards to be washed and then pressed through leather. This being done heat is applied to drive off the mercury from the silver, which is then melted and cast into bars.

In other cases the silver is extracted, after the mineral is roasted, by melting it with lead and borax; the silver unites to the lead forming an alloy. This alloy is to be heated in a porous bone vessel, called a *cupel;* in which case the lead melts through and leaves the pure silver in the cupel.

When it is designed to detect the presence of silver in ore, the ore should be dissolved in the nitric acid; and on adding common salt, the silver will be precipitated in the form of *muriate of silver*, which is to be heated to be freed of its acid and oxigen.

The properties of pure silver are familiar to most people. It is next to gold in malleability, ductility, and lustre. Its color is white; its specific gravity is 10.450, and its hardness is considerable. It melts at 28° of Wedgewood, and in a higher temperature it becomes volatilized. Atmospheric air has no effect on it, unless sulphureous vapors be contained in it. It unites to phosphorus and sulphur. It unites to other metals forming various alloys. With gold it forms what is termed *green gold.* It unites to oxigen, forming an oxid which unites to all the acids, forming various compounds. These compounds may be decomposed by the earths and alkalies.

Silver is oxidated very readily in the nitric acid. This will appear by pouring the acid when moderately strong, on silver in a Florence flask, an effervescence will take place, the nitric acid will be decomposed, oxigen will unite to the silver, and nitrous air will come over. This oxid of silver will then be dissolved in the remaining nitric acid. If this solution be then evaporated it shoots into crystals, which are called *nitrate of silver*, but more commonly *caustic.* It is applied by surgeons to callous ulcers. It has the power of staining animal and vegetable substances of a deep and lasting black; hence, it has been used for staining human hair, but when thus used, it should be very much diluted in water as it has a corrosive property. The article sold in the shops by the term *indelible marking ink*, for marking wearing apparel, is nothing more than a solution of this caustic in water, thickened with a little gum arabic. The fluid called the *silver test*, for detecting counterfeit coin, is a solution of pure silver, considerably diluted. This compound is decomposed and the silver precipitated by the addition of copper.

The muriatic acid has a stronger attraction for the oxid of silver than the nitric acid. Hence, on adding the muriatic acid to a solution of the nitrate of silver, this last is decomposed. The muriatic acid unites to the oxid of silver, forming the muriate of silver, which is an insoluble compound, called *horn silver*. This, heated with three parts of soda, is decomposed, and common salt and pure silver are left in the retort.

The sulphuric acid boiled on silver oxides and dissolves it. Mr. Keir made the valuable discovery, that the sulphuric acid mixed with a little common nitre, or nitrous acid, when heated on silver, dissolved the silver very readily, but did not act on other metals. In consequence of this, the silver may be had perfectly pure in large quantities, by precipitating it with common salt, and heating the precipitate, as is now done at the manufactory of coin at Birmingham in England.

There is a preparation of silver, called Berthollet's fulminating silver, or *ammoniated oxid of silver*, which is the most dangerous preparation known. It is formed by precipitating a weak solution of the nitrate of silver, by lime water. This precipitate is then to be mixed with liquid ammonia, and stired until it assumes a black color, then the fluid is to be poured off, and the black compound to be left in the open air to be dried. This product when ever afterwards moved, most violently explodes. It explodes without fire, and by the mere touch of any substance. But one grain must be prepared at a time, and that with great caution, or the danger will be considerable. The explosion is in consequence of the decomposition of the ammonia; its hidrogen unites to the oxigen of the oxid of silver forming water, which with the nitrogen are instantly rarefied by the heat. The rest of the combinations of silver have not been much examined.

SILVERING.

THERE are various methods of giving a covering of silver to the surfaces of bodies.

Copper may be silvered by rubbing it with the following powder: Take two drams of the cream of tartar, the same quantity of common salt, and half a dram of alum, and mix them well with 15 or 20 grains of silver precipitated, from the nitrate of silver by copper. The surface of the copper becomes white when rubbed with this powder, which may afterwards be brushed off and polished with leather.

The saddlers and harness makers, silver their wares as follows: Half an ounce of silver, precipitated from the nitrate of silver by copper, is to be procured; also common salt and sal-ammoniac, of each two ounces, with one dram of the muriate of mercury, are to be rubbed up together; and made into a paste with water: copper utensils of every kind, which have been previously boiled in a solution of alum and cream of tartar, are to be rubbed with this, after which they are made red hot and polished.

Shell silver for the use of painters, is prepared by rubbing silver leaf with a little honey or gum arabic, which are afterwards to be washed away. This being done, the silver may be put on paper or kept in shells, whence its name.

PLATING.

THE covering of the surface of copper with silver, is called *plating*. It is thus done: Upon small bits of copper, plates of silver are bound with iron wire, generally allowing one ounce of silver to twelve of copper. The surface of the plate of silver is not quite so large as that of the copper. Upon the edges of the copper, not covered by the silver, a little borax is put, and by exposing the whole to heat, the borax melts and facilitates the union between the copper and silver. The copper, with its silver plate, is then pressed under steel rollers, moved by machinery, and is cut at pleasure for use.

FIFTH METAL.

—

COPPER.

THIS is a metal found in most countries combined with arsenic, iron and other metals. More commonly it is found mineralized with oxigen, forming the red or ruby copper, which exists in masses of a red color, moderate lustre, hard and brittle. The green sand of Peru is also an oxid of copper The carbonic acid united to copper forms the ores termed the mountain green, and mountain blue. This metal is also found united to sulphur, and the sulphuric acid.

In order to separate copper from its ores, it is necessary to expose them to a strong heat, in order that all the volatile substances may fly off. In close vessels the copper is then to be melted several times, and the last time a quantity of charcoal should be added to it.

When it is intended to ascertain if copper exists in an ore, the ore should be dissolved in the nitric acid, which will unite to the copper forming nitrate of copper, which when heated with potash is decomposed, leaving behind the oxid of copper.

Copper is known by the following properties: It is of a reddish yellow color, is inferior in malleability and ductility to silver, and has a disagreeable smell and taste peculiar to it. Its specific gravity is about 8.500. It melts at 27° Wedgewood, and if exposed to the air, it burns with a beautiful green flame. It unites to the acids when oxided, forming very poisonous compounds; it unites to the metals, forming very useful alloys, and likewise to sulphur, forming a sulphuret of copper.

NITRATE OF COPPER.

THE nitric acid when poured on copper oxides it, and then dissolves it, forming the nitrate of copper, which, when the solution is evaporated, yields crystals of a fine blue color. If to a solution of this compound a small quantity of lime be added, a green precipitate is formed, which when washed and dried, and rubbed in a mortar with about five part of lime, the mixture acquires a very lively blue color, which is known by the term of *blue verditer*.

SULPHATE OF COPPER;

OR

BLUE VITRIOL.

THE sulphuric acid unites to copper forming the substance called *blue vitriol.* This is a salt usually prepared by burning ores of copper containing sulphur. The sulphur forms sulphuric acid and then unites to the copper forming *sulphate of copper*, or blue vitriol. This is also found in the waters of copper mines.

This salt possesses a very strong styptic taste. It is easily fused by heat, which dissipates its water of crystallization, and changes its color to a bluish white. The sulphuric acid may be extracted by a very strong fire. Lime and magnesia decompose this salt, and the precipitate is of a bluish white color. If it be dried in the open air, it becomes green: ammonia likewise precipitates the copper, but the precipitate is dissolved nearly at the moment that it is formed; and the result is a solution of a beautiful blue color, known by the name of aqua celestis. Blue vitriol is composed of about 30 parts acid, 43 water, and 27 copper.

ACETATE OF COPPER;

OR

VERDIGRIS.

THE *acetic acid* (which gives the sourness to vinegar) unites to copper, forming the acetate of copper, called commonly *verdigris*. This is an article that is prepared in considerable quantities in France by laying thin sheets of copper separated a little from each other in a vessel, in which vinegar is poured. The oxigen of the air oxides the copper, which then unites to the acetic acid forming verdigris, which is then scraped off, dried, and preserved for use. Considerable quantities of it are also prepared at Montpellier, by fermenting the rufuse of grapes with sour wine. The refuse is laid in alternate states, with plates of copper about 6 inches long and 5 broad. In this state they are left for a certain time, after which they are taken out and placed on their edges in a cellar, where they are sprinkled with sour wine. In this situation the verdigris swells up, and is afterwards scraped off, put into bags and sold. All the other vegetable acids unite to copper when oxided. Hence the strongest vegetable juices may be boiled in copper vessels, as the steam prevents the air from oxiding them; but when the boiling ceases the air then oxides the copper, and sometimes the oxid renders the contents poisonous. Hence the propriety of removing the contents from copper vessels so soon as the boiling ceases.

ARSENIATE OF COPPER.

THE arsenic acid also unites to copper, forming a lasting green compound, much used in painting. This is prepared by dissolving potash in heated water, and saturating it with the arsenic acid; then the solution is to be filtered, and a solution of sulphate of copper, called blue vitriol, is to be added gradually; a precipitate will appear, which when dried is used as a paint.

Ammonia also unites to copper. If copper filings be included in a bottle of liquid ammonia and left exposed to the air, the copper is oxided and is then dissolved in the alkali. This preparation of copper as well as some of the above have been used as a medicine in very small doses, but in large quantities they are very poisonous.

Copper is precipitated from its solutions by iron. For this purpose nothing more is required than to leave the iron in a solution of copper, which need not be strong. The phenomena may be rendered very surprising, by pouring a solution of the blue vitriol, (sulphate of copper) upon the clean surface of a bit of iron; for this surface intantly becomes covered with copper. This has given rise to the erroneous belief that the iron was converted into copper.

Copper unites with most of the metals and forms alloys, some of which are of great value.

1. With arsenic it forms *Tombac*, which is of a white color.

2. With bismuth, an alloy of a reddish white color.

3. With antimony, a violet colored alloy.

4. It may be combined with zinc by fusion, and the product is brass. If the *lapis calaminaris* (which is an oxid of zinc) be used, the Manheim gold is obtained.

5. Copper, plunged in a solution of mercury, assumes a white color, which arises from the deposition of the mercury, on the copper.

6. Copper melted with tin, forms *bronze*, or *bell-metal*. This alloy is more brittle, whiter, and more sonorous,

in proportion to the quantity of tin that enters into its combination. It is used to make bells. When it is intended to be applied for the purpose of casting statues, or forming great guns, a larger portion of copper is required, because solidity is very necessary in such cases.

7. Copper unites to silver, which it renders more fusible. One sixteenth of the silver coin is copper. The two metals melted together are used for solders. Hence it is that verdigris is occasionally observed in pieces of silver, at those parts where joinings have been made by means of solder.

8. Copper also unites to gold. One twelfth of the gold coin is usually copper.

Copper is very much used in the arts. All the boilers in dye houses, which are intended to contain compositions that do not attack this metal, are made of copper. It is at present used as a covering for the bottom of ships. Most of the kitchen furniture is made of it. And its combinations with oxigen and the acids, are much used in the arts, and in small quantities as a medicine.

SIXTH METAL.

—

IRON.

THIS exits in larger quantities in nature, than any other metal. It is almost universally found in the mineral and animal kingdoms, and also in many vegetables.

Its ores are numerous, and most of them so generally known, that it would be useless to dwell on them. The names of the most remarkable are as follows:

1 Black ore,
2 Argillaceous ore,
3 Bog ore,
4 Pyrites,
5 Magnetic iron ore,
6 Specular iron ore,
7 Red ore,
8 Brown ore,
9 Carbonate of iron.

However, by far the most common ore, is that called pyrites, in which the iron is united to sulphur. This ore is found in almost every country: the ores are also common in which the metal is united to oxigen, with which it is found combined in different quantities, forming various colored oxids.

In order to separate the metal from its ores, they should be heated in the open air, so that the volatile parts may escape; and then they are to be introduced in furnaces, in contact with the burning fuel. The iron melts and is allowed to run in the sand, forming what is called pig, or *cast-iron*, which is very far from being in a pure state. Besides other substances, it always contains oxigen and carbon. When the oxigen abounds, the iron is brittle; white colored, and is called *white crude iron*. When the carbon abounds, the iron is less brittle; has a dark grey or blue color, and is called black crude iron. The iron in these states, is much more fusible than when pure; hence it may be readily melted and cast into any form. To purify the iron, it is again melted and stirred frequently, until it becomes stiff, in consequence of parting with some of its impurities. In this state it is exposed to the action of a large hammer, which presses out other impurities, which is called *forging;* and the iron is known by the terms forged, wrought, or bar iron. Of the iron so obtained, there are also several kinds. One kind is known to the artists by the term *hot short iron*, which is brittle when heated, but malleable when cold. Another kind is called *cold short iron*, which possesses qualities the reverse of the last. If the iron be repeatedly beat under the hammer it may be had tolerably pure.

When pure, iron is remarkable for the following properties. Its color is a light grey: it is soft, ductile, malleable, and much less fusible than before purification. Its specific gravity is about 7.7. It is distinguished from most substances, by its being attracted by the magnet or loadstone; and acquires, under various circumstances, the property of magnetism. This magnetical property is particularly acquired at the lower part of iron when it is kept in an elevated position. Hence, the lower ends of shovels, pokers, &c. are remarkably magnetic. Instruments of iron, struck by lightning, and when rubbed against each other in the same direction, also become magnetic. It has been supposed, the phenomena of magnetism arise from a modification of the electric fluid; but the majority suppose they proceed from a quality of the metal.

Another property distinguishing iron is, its being softened by heat so that when applied to another piece in that state it unites, which is called *welding*.

STEEL.

WHAT also distinguishes iron, is its capability of uniting to carbon, and forming the well known substance *steel*. The method of forming steel in the manufactories is thus : bars of soft or malleable iron are bedded together in charcoal and placed in a close furnace. For six or eight days, a strong fire is applied. The cementation, as it is called, is judged of by extracting and examining a bar occasionally. When this appears sufficiently changed, the fire is allowed to decline, and the metal is taken out. In this state it forms *blistered steel;* which is afterwards rendered better by hammering it in a forge, or melting it into bars, forming *cast-steel*, a most invaluable article.

A NEW METHOD OF MAKING STEEL.

LATELY a chemist of France, has made a most important improvement in the manufactory of steel, if he can be relied on. His process is the following : take small pieces of iron, and place them in a vessel, with a mixture of chalk (carbonate of lime) and of the earth of Hessian crucibles, equal parts : twelve parts of this mixture are necessary for twenty of iron. The iron is to be covered with the mixture to prevent the contact of the air ; and the whole is subjected to a heat sufficient to melt the iron for one hour. On examination afterwards, the iron will be found converted into steel, equal to that taking eight or nine days for its formation in the usual way.

The quantity of carbon in good steel is about one sixtieth, according to some authors; but others state the quantity to be less. When the quantity is increased beyond this, the steel is rendered more brittle, in proportion to the quantity.

Good steel is distinguished by several remarkable properties. When heated and suddenly introduced into cold water, its hardness is greatly increased. This is what is called *tempering* of steel, the requisite hardness being given by attending to the degree of heat which the metal acquires, and suffering it to cool accordingly. It may be made so hard as to scratch glass, and is at the time rendered more brittle and elastic. When thus hardened, steel may have softness restored by heating it, and allowing it to cool gradually. Steel may also be distinguished from iron, by dropping a little nitric acid on it, the steel is converted to a black color, in consequence of the separation of its coal or carbon; but the iron appears white.--- It is of a light grey color; is susceptible of a very fine polish; is more fusible than iron, and also has a greater specific gravity. It is ductile and malleable, is harder and more elastic than any other metal, and affords sparks, when struck against flints. When exposed to heat, it first turns of a straw yellow, then of a higher yellow, next purple, violet, red, deep blue, and lastly bright blue, when it becomes redhot. Steel is called, according to the new nomenclature *corburet of iron.*

Iron unites to sulphur, phosphorus, and to the metals, forming compounds possessed of various properties which are not very important. It has a very strong attraction for oxigen. Hence, it frequently attracts it from the atmosphere, and forms water at common temperatures, forming what is called the *rust of iron.* When heated in contact with the atmospheric air, it unites to the oxigen more quickly and forms *scales;* if heated in contact with water, the water is decomposed, its hidrogen escapes and the oxigen unites to the metal: If heated in contact with oxigen air, the oxigen unites to it more quickly, and much heat and light are emitted: many of the acids also oxide this metal. Iron is capable of uniting to but two quantities of oxigen; with the first quantity, it forms the *forged scales of iron*, or more properly, *black oxid of iron*, which in the 100 parts contain 27 of oxigen. If this oxid be reduced to powder, and exposed to a high heat in the open air, it unites to more oxigen, which converts it into a *red* or *brown oxid of iron*, which contains in the 100 parts 48 of oxigen. These oxids of iron are used as paints and occasionally as a medicine. If heated very highly in a close vessel they part with their oxigen, particularly if a little charcoal powder be added, and the iron is restored to the metallic state.

Instruments of iron may be prevented from *rusting*, or uniting to oxigen by the following mixture: take 8 pounds of hog's lard, melt it with a little water, and add to it 4 ounces of camphor; when this is dissolved remove it from the fire and add a little plumbago (or black lead.) The iron utensils are to be warmed very much, and then the composition is to be well rubbed on them until they are dry.

The oxids of iron unite to all the acids forming various salts. The few which have been found of much consequence are the following:

COPPERAS;

OR

SULPHATE OF IRON.

—

THE sulphuric acid diluted with water, oxides and dissolves the iron very quickly. The solution when evaporated, deposits the well known article of commerce called *copperas*, or *green vitriol;* but this is more properly termed *sulphate of iron.* This compound is prepared on a large scale, by burning the iron ores containing sulphur (called pyrites) when exposed to the air. The sulphur unites to oxigen forming sulphuric acid, which unites to the oxid of iron forming the salt copperas, which is washed off with water. In this water, old iron is added to unite to the excess of acid. The solution is then evaporated, and the salt crystallizes. It contains a considerable quantity of water, of which it may be freed by heating it; and the salt then exists in the form of a white powder.

This powder mixed with dry nut galls, forms a dry ink, which several persons sell as a secret, and which requires only the addition of a little water to make it fit for use. This salt is chiefly used in the arts, particularly in dyeing black.

THE MURIATE OF IRON.

—

THE muriatic acid also unites to the oxids of iron forming a *muriate* of iron. A preparation of this is commonly used as a medicine, called *flowers of steel.* If one pound of the muriate of ammonia (sal-ammoniac) in powder, be mixed with one ounce of steel filings, and if this be heated together in a proper vessel a compound comes over, which is much used as a tonic in medicine, called *flowers of steel.*

CHALYBEATE WATERS.

THE oxid of iron readily unites to the carbonic acid. The common rust of iron contains this acid, which it absorbs from the atmosphere. If a quantity of the rust of iron be introduced in water impregnated with carbonic acid, the oxid of iron is dissolved, and this forms the *chalybeate waters*, so generally used as a tonic by invalids, when found in springs. The artificial combination possesses all the virtues of that found in nature.

PRUSSIATE OF IRON;

OR

PRUSSIAN BLUE.

A VERY singular mistake gave rise to the discovery of a compound of a beautiful blue color, known in common by the term Prussian blue. This is formed by an oxid of iron united to an acid, called the Prussic acid; and in the new nomenclature it is termed *prussiate of iron.* Mr. Chaptal thus introduces this subject:

" A chemist of Berlin being desirous of precipitating a decoction of cochineal with fixed alkali, borrowed of Dippel an alkali, upon which he had several times distilled animal oil. As the decoction of the cochineal contained sulphate of iron, the liquor immediately afforded a beautiful blue. The experiment being repeated was followed with similar results; and this color became an object of commerce, under the name of Prussian blue."

" To make Prussian blue, four ounces of alkali are mixed with the same weight of dried bullock's blood, and the mixture is to be exposed in a vessel to a strong heat; to stifle the flame, the vessel is to be kept covered, and the fire is to be kept up until the mixture is converted into a red-hot coal. This coal is then thrown into water which is afterwards filtered, and evaporated considerably. On the other hand two ounces of the sulphate of iron, and four ounces of alum are dissolved in a pint of water. The two solutions are mixed and a blueish disposition falls down, which is rendered still more intensely blue, by washing it with muriatic acid."

" Such is the process used in chemical laboratories, but in the works in the large way, another method is followed. Equal parts of raspings of horn, clippings of skins or other animal substances are taken, and by means of heat, converted into charcoal. Ten pounds of this coal are mixed with thirty pounds of potash, and the mixture is heated in an iron vessel. After continuing twelve hours redhot, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered, and the solution mixed with another, consisting of three parts of alum and one of the sulphate of iron, when the Prussian blue instantly appears in the form of a precipitate."

The celebrated Scheele was the first who shewed that the Prussian blue contained an acid. This acid is called the Prussic acid, and it may be thus procured. Take two ounces of powdered Prussian blue, and put it in a glass vessel, with one ounce of red precipitate and six of water. This mixture is to be boiled for some minutes, and constantly stirred. It then assumes a yellow color, inclining to green. The fluid being filtered, two ounces of boiling water are to be thrown on the remainder. This liquor is a *Prussiate of mercury*, which cannot be decomposed by acids or alkalies. The solution is then poured into a bottle, in which an ounce of newly made filings of iron are put. A little sulphuric acid is then to be added, and the whole agitated for some minutes. The mixture becomes perfectly black, by the reduction of the mercury. After suffering it to rest for some time, the liquid is decanted, put into a retort, and distilled, by a gentle fire. The operation must be discontinued when one quarter of the fluid passes over. As this product contains a small quantity of sulphuric acid, it should be introduced in another retort with a little chalk, and be distilled by a very gentle fire. The Prussic acid then comes over in a state of the greatest purity. It has a particular smell and a sweet taste. Its exact composition is not known, but suspicions have arisen that it does not owe its acid properties to oxigen.

The Prussic acid has a very strong attraction for the oxid of iron, and in consequence of forming with it a blue compound, it answers as an excellent test to detect the presence of iron in any fluid. If lime water be digested upon Prussian blue, the color is lost, and the water acquires a yellow color. This is a prussiate of lime, and answers very well to detect the presence of iron. Ammonia by means of heat destroys the color of the Prussian blue, and also the pure fixed alkalies, potash and soda.

Prussian blue has also been found in the earth in small quantity. It is an article much used in the art of dyeing.

The uses of iron are so important, that they are too generally known, to need dwelling on in this place. The happiness and power of nations materially depend upon this metal. It has been considered as the soul of the arts. Under the form of cast iron, it serves to construct many machines and utensils. In bar iron, it answers for many purposes: it unites force and resistance to flexibility and elasticity. In the state of steel, it is fitted for the largest machinery, and also for the most delicate instruments.--- Its capability of acquiring the magnetic power, has given birth to the *mariner's compass*, which has given inexhaustible sources of industry and wealth to the world. Besides these, as before remarked, it is used in the healing art, and in the arts of dyeing and painting.

DISCOURSE VIII.

SEVENTH METAL.

—

TIN.

THIS metal is found comparatively in but small quantities. It is met with in greatest abundance in Cornwall in England, and in lesser quantities in the mines of Bohemia, Saxony, the island of Benca, and in the East Indies. It is also found in Chili, and Mexico in South America. It exists only in a state of combination with oxigen, it forms an ore of a white or dark brown color, and with sulphur it forms the ore called *tin pyrites*.

To extract the metal from its ores, it should be heated in the air, so that the volatile parts may escape. It should then be mixed with charcoal powder, and exposed to a pretty strong heat in a furnace. It melts at about 420° Fahrenheit, and may then be allowed to run off.

Pure tin is of a brilliant white color, though not so white as silver; it is one of the most fusible metals, and also the lightest; its specific gravity not exceeding 7 : 299 after hammering. By an intense heat it is volatilized. It easily bends, and makes a noise called the *crackling of tin*. It is exceedingly soft and ductile, and may be hammered into leaves not thicker than one thousandth of an inch. It has scarcely any sound when struck against hard bodies. It resists the action of the air. It unites to sulphur and also to the metals, forming some useful alloys.

About one thirty-seventh of tin scarcely alters the properties of gold; but a larger quantity renders it brittle, and changes its color. With silver and platina, it forms alloys of no importance. It readily unites to mercury in any proportion. If one part of zinc and tin be melted together and mixed and agitated together in a wooden box, with two parts of mercury, a powder will be formed which is applied to electrical machines, with the effect of increasing considerably their power of collecting electricity.

LOOKING GLASSES.

ARE silvered on one side, or covered over with a preparation which reflects the light, by an alloy of tin and mercury. For this purpose, tin foil is smoothly placed on a flat stone or table, and mercury, in which some tin has already been dissolved, is poured upon it, and spread with a feather or brush of cloth, until it has united to every part. A plate of glass is then cautiously slid upon it from one end to the other end, in such a manner that part of the unnecessary mercury is driven off, before its edge. The remainder has united to the tin. The glass is then loaded with weights all over, so as to press out still more of the mercury, which runs off by inclining the table towards a side. In a few hours the union between the glass and alloy is completed, and the weights may be removed. In the small way, about two ounces of mercury are requisite for covering three square feet of glass.

TINNING OF IRON.

IRON is tinned in the following manner: Plates of iron, properly thinned, are immersed in water, acidulated with a little sulphuric or muriatic acids, in order to free them completely from rust; they are then scoured bright, and placed in a pot filled with melted tin, the surface of which is covered with suet, or pitch, to prevent the surface of the tin from oxiding. The plates of iron being then suffered to pass through it, the tin will unite with them, so as to cover each side of the plate with a thin white coat, constituting what are called *tin plates*. In the same way stirrups, buckles, bridle bits, &c. are covered with coats of tin.

TINNING COPPER VESSELS.

VESSELS of copper, when used for cooking, are commonly covered with a thin coat of tin, to prevent the copper from uniting to oxigen, and dissolving in the food, so as to render it poisonous. These ve-sels are said to be *tinned.* To do this, their interior surface is scraped clean with an iron instrument, and rubbed over with sal-ammoniac, (muriate of ammonia.) The vessel is then heated, and a little pitch thrown in it and allowed to spread on the surface. Then a bit of tin is applied over the hot copper, which instantly assumes a silvery whiteness. The object of the first steps is to have the copper free from all rust, as the tin will not unite to the oxid of the metal. The coat of tin so applied is exceedingly thin. Not more than twenty-five grains of tin are necessary for tinning a copper bason one foot in diameter ; and it is useless to make the coat thicker, as the tin melts and runs off when the vessel is heated.

The other alloys of tin have not been found of importance.

OXIDS OF TIN.

TIN unites to oxigen in different quantities. If tin be melted in a ladle exposed to atmospheric air, a grey covering will appear, which forms wrinkles : when this is taken off, it is soon succeeded by another, and in this manner the whole metal may be converted into a powder, which is an *oxid of tin* of a grey or yellow color. It is this oxid of tin which the makers of pewter spoons and plates who usually travel over the country, call the *dross of tin.* They are very careful to skim the metal while fluid as often as posssible, to clear it of the dross, and by this means they avoid giving those who employ them any more of the old pewter than that which they cannot contrive to carry off.

This pretended dross they readily convert into good tin, by heating it in closed vessels in contact with charcoal powder.

If this oxid of tin be exposed to a strong heat in an open vessel, and be stirred up repeatedly, it unites to more oxigen and appears of a white color. This is *white oxid of tin*, commonly called *putty of tin*. It is used for polishing glass for tellescopes, marble, steel, &c. United to glass, it deprives it of its transparency, and renders it like white enamel. This oxid of tin may also be prepared by heating tin in contact with nitric acid, when a violent action ensues and the whole of the tin is converted into a white powder, or the oxid of tin. If a little water and potash be added to the tin with the nitric acid, then the hidrogen of the water, and the nitrogen of the acid unite and form ammonia.

This white oxid of tin by fusion, unites to sulphur and forms the *aurum musivum*, more properly called yellow sulphurated oxid of tin, an article much used to give a beautiful color to bronze, to increase the strength of electrical machines; and it is employed by japanners, for many articles intended to have the appearance of metallic gold. The process to form it is thus: twelve parts of tin are melted in a vessel by a brisk fire, and three of mercury are then added to it. This mass is to be reduced to powder in a stone mortar, and then very well rubbed up with seven parts of sulphur and three of sal-ammoniac. The mixture is to be exposed to heat as long as any white vapors are disengaged; the heat is then moderately increased, and at the bottom of the vessel the *aurum musivum* remains, with a little sulphuret of mercury and muriate of tin. If the heat have been too strong, only the black sulphuret of tin remains.

The action of acids upon tin varies according to the degree of purity of the metal. The oxides of the metal unite very readily to the acids.

The sulphuric acid dissolves tin by the assistance of heat; but a part of the acid is decomposed, and flies off in the form of sulphureous acid.

The muriatic acid dissolves tin, whether cold or heated; at the same time emitting a very fetid air. The solution is yellowish, and affords crystals of the muriate of tin by evaporation. The oxi-muriatic acid oxides, and dissolves this metal much more speedily. The liquor known by the name of the *fuming liquor of Libavius*, appears to be an oxi-muriate of tin To make this preparation, tin is alloyed with one fifth of mercury, and this alloy in powder is mixed with an equal weight of corrosive sublimate. The whole is then put in a retort, a receiver adapted, and distillation proceeded upon, by applying a gentle heat An insipid liquor passes over first, which is followed by a sudden eruption of white vapors, which condense into a transparent liquor, that emits a considerable quantity of vapors by mere exposure to the air.

Tin when dissolved in the nitro-muriatic acid is used for the formation of a composition to dye scarlet. The common aqua fortis of the shops is commonly employed instead of the above acid properly made. In consequence of the composition of aqua fortis varying, the dyers frequently complain, that the aqua fortis precipitates; which happens when it contains too small a quantity of muriatic acid; or that the color is obscure, which happens when the nitric acid is too small in quantity. The first inconvenience is remedied, by dissolving common salt, or sal-ammoniac in the aqua fortis; and the second by adding nitre. The most accurate proportions for making a good solvent for tin are two parts of nitric and one of muriatic acid.

Most of the tin in commerce is alloyed with other metals. That of England contains copper and arsenic.

When tin contains arsenic, the solution in the muriatic acid exhibits a black powder, which consists of arsenic separated from tin. This method is capable of rendering the two thousandth part of arsenic in tin perceptible.

If the tin contain copper, the muriatic acid, which attacks tin with facility, precipitates the copper in the form of a grey powder. The copper may likewise be precipitated, if a plate of tin be immersed in a solution of the alloy.

In order to ascertain the presence of lead in tin, the nitric acid must be poured on it---the acid dissolves the lead, and leaves the tin in the form of a white powder. And the lead may be detected in the acid.

EIGHTH METAL.

LEAD.

This metal is found in large quantities in many parts of the earth, generally mineralized with oxigen, and sulphuric, carbonic and phosphoric acids. The largest quantities are found united to sulphur, forming the ore called *galena*, which feels greasy and has a blueish lead grey. The following are the names of the different ores, in which this metal has been found:

1 Galena,
2 Blue lead ore,
3 Black lead ore,
4 Earthy ore of lead,
5 Carbonate of lead, or white lead,
6 Sulphate of lead,
7 Phosphate of lead,
8 Chromate of lead,
9 Molydate of lead,
10 Arseniate of lead.

Besides several others useless to mention.

To separate lead from its ores it is first exposed to heat, which carries off the volatile parts. It is then introduced in a furnace in contact with the burning fuel, where it melts, and may be drawn off from the bottom. In this state it commonly contains a little silver. To free it from this it is introduced in a refining furnace and melted. Here a quantity of fresh air is applied to the surface of the lead by means of a large bellows. This oxides the lead and converts it into the yellow scaly oxid, which is driven off from the silver that remains pure in the furnace. This oxid is then to be melted in contact with powdered charcoal, when it parts with its oxigen, and the lead falls at the bottom in a pure state.

Lead is of a blueish white color when first cut; but it soon tarnishes on exposure to the air. It is among the softest and least elastic metals. It is malleable and ductile, but not in a very great degree. Its specific gravity is 11.435. It unites to sulphur and phosphorus; forming, however, no useful compounds. It melts at 540° Fahrenheit, and renders other metals more fusible.

When exposed to the air, lead slowly unites to oxigen, forms a grey powder, which afterwards becomes white. This union with oxigen, may be much hastened, if the metal be heated. If the lead be melted and stirred up in contact with air, it readily unites to oxigen, and appears in the form of a grey powder, which then assumes a lively yellow color, forming the pigment called *massicot;* and if the heat be continued, this massicot absorbs more oxigen and assumes a red color. It is then called *minimum*, or red lead. If this be melted it parts with some oxigen, and is converted into *lytharge*. The red oxid of lead contains in the 100 parts, 12 of oxigen, which it will give up as all the rest of the metallic oxids if heated in a retort, particularly in contact with coal The preparations of lead are used as paints when mixed with oils On account of their fusibility, they are used in glass houses, to assist the fusion of the glass; to render the glass softer, heavier and more susceptibe of being cut and polished. These oxids of lead are likewise used to harden oils, or to render them more drying by boiling the oils over them. In this operation, they part with their oxigen which unites to the oils.

The oxids of lead readily unite to the acids, forming compounds, most of which are of no importance. The most remarkable are, the

SUGAR OF LEAD;

OR

ACETATE OF LEAD.

IF vinegar, which owes its acidity to the acetic acid, be poured on the oxids of lead, the acid unites to the oxid and forms the *sugar of lead;* which is used as a medicine, in small doses of 2 or 6 grains, and also in applications to allay inflammation.

WHITE LEAD;

OR

CARBONATE OF LEAD.

—

THE white lead of commerce is formed by allowing the steam of vinegar to pass through thin sheets of lead. The lead is oxided, and unites to *carbonic acid*, forming a white powder, which should be dried. This is used as a paint, and as putty. It is a *carbonate of lead.*

MURIATE OF LEAD;

OR

PATENT LONDON YELLOW.

—

THIS compound which has lately been much used as a paint, is thus formed: Four parts of litharge, and one of common salt, (muriate of soda) are to be rubbed up together and wetted sufficiently with water to form a paste. The muriatic acid then unites to the oxid of lead, and the soda is left in a free state. The muriate of lead is to be exposed to a moderate heat, when it becomes fit for use.

SULPHATE OF LEAD.

THE sulphuric acid has a remarkably strong attraction for lead, and attracts it from all the rest of its combinations, forming with it an insoluble compound. Hence it is a good test, by which the presence of lead in fluids may be detected. The other compounds of the oxids of lead with the acids have not been much examined.

Lead unites to other metals, forming various alloys. When combined with copper, it is used for making the largest types for printing. Three parts of tin and one of lead form an alloy called *ley pewter*, which is harder than tin. *Tin-foil* is generally composed of two parts of lead and one of tin. This being more fusible than either of the metals separately, it is used to connect different metals together, or as a solder.

Lead in the metallic state is used to make water pipes, to line tea chests, to form bullets and shot, &c. Shot are usually formed by melting lead with a little arsenic, which renders it more brittle; it is then poured into a sieve, which has round orifices in it, and which stands over water. The lead assumes the round form as it enters the water.

NINTH METAL.

ZINC.

ZINC is found in nature confined with oxigen, carbonic acid, sulphuric acid, and with sulphur. With oxigen it forms the ore called *calamine*, or lapis calaminaris, of a grey, white, yellow or brown color. The most abundant ore is that called *blende*, in which the zinc is united to sulphur: This is of various colors, brown, yellow, hyacinth, black, &c. and with various degrees of lustre.

In order to obtain zinc from its ores, they must first be roasted (or heated exposed to air) and then mixt with half their weight of charcoal in an earthen retort, connected at its end with water. On applying heat, and increasing it for some time, the zinc melts and sublimes, and is found deposited at the neck of the vessel.

Zinc may be distinguished by the following properties: It is of a brilliant white color, with a blueish tint. It possesses some degree of ductility, and may be extended when carefully pressed. It is a very strong conductor of galvanism. Its specific gravity is 7 190: It melts at 700° Fahrenheit, and by an increase of heat, it is volatilized unchanged. It undergoes very little alteration from exposure to atmospheric air; nor is it changed by water, unless the temperature be high, in which case the decomposition of the water is rapid; its oxigen unites to the zinc and the hidrogen escapes in the form of air. It has a very strong attraction for oxigen. When heated it burns with a very bright flame and flakes of exceedingly white and light matter, like cotton, will rise at the same time. This is the white oxid of zinc, which is called, commonly, philosophical wool, pompholix, or nihil album. This oxide may be fused into a kind of glass, of a beautiful yellow color, by means of a violent heat.

The attraction of zinc for oxigen is so strong that most of the metallic solutions are decomposed, when zinc is added to them. We have an example in the *lead tree.* This is formed by dissolving one part of the sugar of lead in 35 or 40 of distilled water, and suspending a bit of zinc in the middle of a glass bottle containing it. The zinc attracts the oxigen of the sugar of lead (acetate of lead) and is dissolved, while the lead is gradually deposited on the zinc, of a moss-like appearance and metallic splendor, which sometimes has the shape of a tree.

NITRATE OF ZINC.

THE nitric acid diluted rapidly, oxides zinc, and then dissolves it; nitrous gas being emitted. The solution, if evaporated, yields crystals of the *nitrate of zinc,* which has not been found of much consequence.

WHITE VITRIOL;

OR

THE SULPHATE OF ZINC.

THIS salt is formed by the union of sulphuric acid with zinc. If the diluted sulphuric acid be added to zinc, the water is rapidly decomposed; its hidrogen escapes in the form of air, while its oxigen unites to zinc, forming an oxid, which then unites to the acid and is dissolved. The solution, if evaporated, will yield the *white vitriol* of the shops, an article much used to allay inflammations, when dissolved in water and applied to the inflamed parts. In doses of twenty or thirty grains it is a quick emetic. This is the only preparation of zinc with an acid, which has been much attended to.

For the purposes of commerce, it is made by the decomposition of the ore *blende*, which is composed of sulphur and zinc. The ore is heated and thrown into cisterns of water, where it is left for twenty-four hours. The roasted mineral is three times extinguished in the same water; after which the water is evaporated and put into coolers. At the end of fifteen days the water is decanted, in order to separate the crystals of the sulphate of zinc. These crystals are afterwards fused in iron vessels, and the liquor is poured into coolers, where it is stirred till it congeals.

Zinc unites to other metals, forming alloys which are very useful, and which were mentioned while considering copper and tin.

TENTH METAL.

—

BISMUTH.

THIS is a metal not found in great quantities, or of much consequence. It is generally found in the metallic state, and is procured from the mines of Saxony, Sweden, &c. To obtain the metal in a state of purity, it is only necessary to expose the ore to a strong heat, in a closed retort. The metal sublimes, and may be taken from the neck of the retort.

Bismuth is of a reddish white color, is destitute of taste and smell, is possessed of but little ductility or malleability, and is soft enough to be cut with the knife. Its specific gravity is 9.800. It is brittle, and can readily be reduced to small pieces. It melts at a temperature of 460° and in a higher heat is volatilized. If heated, exposed to the air, it readily unites to oxigen, forming a white oxid of bismuth. This oxid unites to the acids, forming compounds of no known value. The oxid is prepared by pouring the nitric acid on the metal, which oxides and dissolves it. Then, if the solution be diluted with water, the oxid of bismuth falls to the bottom, in the form of a beautiful white powder, which was formerly much used to whiten the skin. But whenever it comes in contact with the fetid airs, it turns of a *black* color. It is used in pomatum to blacken the hair. When this oxid is dissolved in an acid, it may be used as a sympathetic ink. On writing with it on paper, the characters will only appear when the paper is held over the vapor arising from moistened sulphuret of potash.

Bismuth unites to most of the metals, forming various alloys. When fused with gold, the alloy retains the color of the bismuth, and is brittle. This metal when united to silver does not render it so brittle as gold. It diminishes the red color of copper, but is deprived of its own color by uniting with lead, and the alloy appears of a dark grey color. When bismuth is mixed with a small portion of tin, it gives it a greater degree of brilliancy and hardness. It is remarkable, that a mixture of eight parts of bismuth, five of lead, and three of tin, is so fusible that it remains fluid in boiling water.

Bismuth unites to mercury and forms a fluid alloy, a circumstance which has led some unprincipled druggists to mix it with that metal. The fraud may be known, as the mercury does not appear quite as fluid as when pure. It may also be detected, by dissolving the mixture in nitric acid; and on adding water the bismuth will be precipitated.

ELEVENTH METAL.

ANTIMONY.

THIS is one of the most noted metals which has excited a great deal of attention, particularly among the alchemists, who called it *sacred lead*, *radical principle of metals*, &c It is the base of the numerous medicines in the shops, called antimonial.

Antimony is but rarely if ever found native. Various ores containing it are found in Germany, Hungary, France, Spain, Britain, Sweden, Norway, &c. They are generally blended with various silicious earths. The most remarkable ores are:

1 Grey ore of antimony.
2 White oxid of antimony.
3 Red oxid of antimony.
4 Arseniate of antimony.

But by far the most abundant ore is the *grey* ore of antimony, in which the metal exists united to sulphur. This ore is heated in a proper place, and the combination of sulphur and antimony, being very fusible, the compound readily runs out at the bottom. This compound is called *crude antimony*, in common, and was supposed at one time to be the pure metal. Two methods are practised to separate the sulphur from this crude antimony, or *sulphuret of antimony*.

The first method is by the slow and gradual oxidation of the metal, in which case, a grey oxid is formed. This grey oxid, urged by a violent heat, melts and forms *the glass of antimony*, which when the fusion is complete is transparent. This glass of antimony, when bedded in charcoal and heated most intensely hot, parts with its oxigen, and leaves the antimony in a state of purity.

The second method of obtaining the metal from *crude antimony*, consists in heating it in a proper vessel, by adding to eight parts of it six of tartar, and three of nitre. This mixture is then kept in a high heat till the antimony melts. Or if the crude antimony be heated with copper, silver or iron, its sulphur unites to these metals, and the antimony remains pure.

Antimony is of a greyish white color, having a slight blueish shade, and very brilliant. It is very brittle, and appears to be composed of a number of very small plates. Its specific gravity is 6.702. It is the lightest, and among the hardest and most infusible metals. It decomposes water very readily.

This metal unites to others, forming alloys possessed of various properties, but most of them are of no use. The most valuable is that formed for printers' types, which are composed commonly of ten parts of lead, and one of antimony, to which a little zinc and bismuth are sometimes added.

Antimony unites to oxigen in different proportions. When fused and exposed to the air, it emits white fumes, known by the name of *argentine snow*, or flowers of antimony. These fumes are partially soluble in water, to which they impart emetic qualities.

When this metal is reduced to powder and exposed to a dull red heat, in an open vessel, oxigen is absorbed, and a *grey oxid of antimony* is formed. And if this grey oxid be exposed to a still higher heat, larger quantities of oxigen combine with it, and the product is *a white oxid of antimony*. If this white oxid of antimony be exposed to a still stronger heat, it fuses and forms a nitrous oxid of antimony, commonly called *glass of antimony*. This compound is much used as a medicine. It is possessed of very corrosive properties. But when rubbed up with wax, which is afterwards burnt off, this corrosive property is lessened. It then constitutes the *cerated glass of antimony*, so much used in dysenteric affections.

The glass of antimony is used in the preparation called antimonial wine. For this purpose, nothing more is necessary than to add a little of it to a bottle of wine. The wine dissolves it in proportion to its acid; and hence the strength of antimonial wine varies very much, as do the acids of wines.

TARTAR EMETIC,

OR

ANTIMONIATED TARTRITE OF POTASH.

THE preparation commonly called *tartar*, or *tartar emetic*, is made of this glass of antimony and common cream of tartar. The method of making it is not the same among different apothecaries: hence the properties of tartar emetic are found to vary so much. The best method of making it is stated to be the following:

Take very transparent glass of antimony, grind it very fine and boil it in water, with an equal weight of the cream of tartar. Then filter the fluid and evaporate it by a gentle heat. When it is then allowed to rest, crystals of tartar emetic will be deposited. These will operate very well in doses of from one to four grains. This compound is termed in the new nomenclature *antimoniated tartrite of potash*.

BUTTER OF ANTIMONY;

OR

MURIATE OF ANTIMONY.

THE muriatic acid acts upon antimony, but slowly. But if two parts of corrosive sublimate (oxi-muriate of mercury) and one of antimony, be distilled together, a very slight degree of heat drives over a matter which is called butter of antimony. By a very moderate heat, this may be rendered fluid, and in consequence, may readily be poured from one vessel to another. This preparation is used sometimes to corrode animal parts. When diluted with water, a white powder falls down, which is a pure oxid of antimony. It is generally called *powder of algaroth*.

NITRATE OF ANTIMONY.

THE nitric acid is decomposed upon this metal with great facility. It oxides a considerable part and dissolves a small portion, which is suspended in the fluid, and may be crystallized by evaporation. The oxide remaining, is very white, and is called *bezoar mineral*.

JAMES' POWDER.

The phosphoric acid also unites to an oxid of antimony and forms a celebrated febrifuge powder, called James' powder. The exact composition of this medicine is not generally known, and consequently it is chiefly prepared by a few apothecaries in England. Its dose is from 5 to 10 grains.

The alkalies do not sensibly act upon antimony, but when combined with sulphur they operate very readily. This has led to the preparation of a very valuable medicine, called

KERMES' MINERAL;

OR

GOLDEN SULPHUR OF ANTIMONY.

THIS medicine may be made by boiling ten or twelve parts of a pure alkaline solution, with two pounds of the crude or sulphuret of antimony. The boiling is continued for half an hour, after which the fluid is filtered, and much of the medicine falls to the bottom on cooling. Fresh alkali may be digested, until the whole of the antimony is consumed. This preparation has somewhat of an orange color. It is termed by the chemists *hidro-sulphuret of antimony*. In doses of from one to five grains, it is given to adults to promote perspiration. It sometimes operates as an emetic. In doses of about one ounce it is given to horses.

Besides the above preparations of antimony, the metal is given in the form of a pill, in the metallic state. It appears to be soluble in the stomach, in small quantities, and excites slight purging. This was called the *perpetual pill*, as it was frequently kept for ages in families, who after taking and voiding it, preserved it for further use.

TWELFTH METAL.

ARSENIC.

THE substance which is sold in commerce under the name of arsenic, is a metallic oxide of a glittering whiteness, sometimes of a vitreous appearance; exciting the impression of an acid taste on the tongue; volatile when exposed to the fire, in which situation it rises in the form of a white fume, with a very evident smell of garlic.

This metal is scattered in great abundance over the mineral kingdom. It is found in black heavy masses of little brilliancy, called *native arsenic*, in different parts of Germany. Mineralized by sulphur, it forms two ores which are met with about mount Vesuvius; the one is of a yellow color called *orpiment*, the other has a red appearance and is termed *realgar;* this last contains most sulphur. This metal is also found alloyed with cobalt, antimony, tin, copper, iron, and other metals. When united to oxigen it forms *native oxid of antimony*, which is found of an earthy appearance, and of a whitish grey color.

Arsenic is usually extracted from the ore containing oxigen. It is introduced in a tightly closed vessel with charcoal powder and a little potash, and then heat is applied. The arsenic sublimes and adheres to the top of the vessel, from which it is to be taken and preserved under water.

This metal is very brittle, and if recently broke, its color is between tin white and lead grey; but on exposure to air, it soon loses its metallic lustre, and turns at last dull and of a black appearance. Its specific gravity is about 8.000. It is entirely volatilized when heated to 356° Fahrenheit, so that it readily sublimes. It readily unites to oxigen and to various metals, and it is to most animals a deadly poison.

If arsenic be heated, while exposed to atmospheric air it readily burns, and when made redhot, it burns with a blue flame and emits fumes of a garlic smell, by which fumes and smell the presence of the metal in any compound thrown in the fire may frequently be detected. These fumes are a compound of arsenic and oxigen, which may readily be condensed; and they then constitute what is commonly called arsenic. This oxid of arsenic may be volatilized: it has a sharp caustic taste, and is soluble in water. It is capable of uniting to an additional quantity of oxigen, forming a compound possessed of all the properties of acids, and called *arsenic acid*. This acid unites to the alkalies, earths, and metallic oxids, forming compounds called *arseniates*, which have not yet been found of consequence.

Arsenic unites to copper forming *a white alloy*. By this the presence of the metal may readily be detected in most instances. If the substance supposed to contain the metal be placed between two bright copper plates, bound together by wire and excluded from the air entirely, and then exposed to a strong heat the arsenic unites to the copper and turns it of a white appearance as may be seen on examination after the whole is cooled.

Arsenic is used by the dyers: it is a component part of some *glazes*, and in the state of realgar and orpiment it is much used in painting. In small doses, commencing with one sixteenth of a grain and gradually increasing the quantity it i given with great success in cases of cancer and intermittent fever. Mr. Chaptal concludes this subject with the following judicious remarks:

" This metal, which is very abundant, and very frequently met with in mines, causes the destruction of a number of workmen who explore them. Being very volatile, it forms a dust which affects and destroys the lungs; and the unhappy miners, after a languishing life of a few years, all perish sooner or later. The property which it possesses, of being soluble in water, multiplies and facilitates its destructive power; and it ought to be proscribed in commerce, by the strict law which prohibits the sale of poison to unknown persons. Arsenic is every day the instrument by which victims are sacrificed, either by the hand of wickedness or imprudence. It is often mistaken for sugar; and these mistakes are attended with the most dreadful consequences. Whenever there is the least reason to suspect its presence, the doubt may be cleared up by throwing a small quantity of the powder upon heated coals. The white fumes, and the smell of garlic, are indications of the presence of arsenic. The symptoms which characterize this poison are, a great constriction of the throat, the teeth set on edge, and the mouth strongly heated; an involuntary spitting, with extreme pains in the stomach, vomiting of glairous and bloody matter, with cold sweats and convulsions.

"Mucilaginous drinks have been long ago given to persons poisoned by arsenic. Milk, fat, oils, butter, &c. have been much employed. Mr. Navier has proposed a more direct counterpoison. He prescribes one dram of sulphur of potash, or liver of sulphur, to be dissolved in a pint of water, which the patient is directed to drink at several draughts. The sulphur unites to the arsenic, and destroys its causticity. When the first symptoms are dissipated, he advises the use of mineral sulphureous waters. He likewise approves of milk. Vinegar, which dissolves arsenic, has likewise been recommended by Mr. Sage."

THIRTEENTH METAL.

—

MANGANESE.

THIS metallic substance seems, after iron, to be the most frequently diffused metal through the earth. Its ores are very common. It is always found united to oxigen, in different quantities. These oxids are distinguished by their color, there being one species, called the *grey oxid of manganese;* then there is the reddish white oxid, and the *carbonate of manganese.* All these combinations have an earthy texture, and are heavy, and generally contain considerable quantities of iron. Their color is sometimes black, grey, and seldom white. The article sold by potters under the name of *manganese,* is an oxid of manganese. Dr. Woodhouse of Philadelphia states, that great quantities of it may be obtained in this country on the Leheigh river. A portion which he analyzed, that was brought from that place, was found of very good quality.

This metal may be obtained in a state of purity by mixing the oxid, finely powdered, with the charcoal, and exposing the whole to a very intense heat in a retort. The oxigen unites to the coal and escapes in the form of fixed air, leaving the metal in a tolerable state of purity in the retort.

Manganese is of a whitish grey color, and when broken has a very irregular appearance. It soon loses its lustre when exposed to the air. Its specific gravity is about 6.850. It is very hard and brittle. It is the most difficult metal to fuse, next to platina. Its attraction for oxigen is so strong, that in a low temperature it attracts it from the atmosphere, and consequently can only be kept pure under oil or water. It is the most combustible metal; it unites to different quantities of oxigen, and the color of the oxid depends on the quantity. It unites to other metals, forming alloys of no value.

The sulphuric acid unites to manganese very readily. When the metal is in its common state, that is united to great quantities of oxigen, on putting it in a retort with sulphuric acid and applying a gentle heat, great quantities of oxigen air will come over in a state of purity. Dr. Woodhouse in a paper in the Medical Repository recommends this method of obtaining oxigen air very strongly; and Chaptal states, that he procured more than five pints of pure air from one ounce of the metalic oxid, by means of the sulphuric acid. It seems that the metal contains too great a portion of oxigen in its usual state to unite to the sulphuric acid, and consequently it parts with oxigen when the acid is added to it, and only retains a small quantity, with which it combines to the acid forming the sulphate of manganese. This sulphate of manganese is soluble in water and by evaporation may be made to crystallize. It has not been found of use.

The nitric acid dissolves manganese with effervescence. The solution of the nitrate of manganese has frequently a dull color, and assumes a red color with difficulty. This solution does not afford crystals.

The muriatic acid dissolves manganese; but when the acid is poured on the common oxid, the oxi-muriatic acid, of which we have treated, is formed. In consequence of this, the metal is frequently employed in this manner, to yield the above air, which is coming into great demand.

The carbonic acid unites to the common oxid of manganese. Indeed the manganese of potters contain considerable quantities of this air. Hence on heating it in a retort, to obtain oxigen air, a considerable quantity of carbonic acid comes over. All the other acids combine with this metal; but they do not form compounds of known value.

Manganese is precipitated from its solutions by the alkalies, in the form of a whitish, gelatinous matter; but this precipitate soon loses its color, and becomes black on the contact of the atmosphere. This arises in consequence of the absorption of oxigen air. Mr. Chaptal, on observing this, proposed to employ this precipitate in the construction of an eudiometer, on the same principle that the sulphuret of potash is used. The diminution of a given bulk of air in its presence, would indicate the quantity of air which had been present.

In the arts the black oxid of manganese is used in considerable quantities. Glass makers use it in small quantities, to deprive glass of green and yellow colors; hence it has been called the *soap of glass makers*. It probably acts by parting with its oxigen, which uniting to the coloring matter destroys its color. In large quantities it renders glass of a violet color. The potters use it to give their wares a black color; and the chemists employ it in considerable quantities to yield oxigen air.

Since it yields oxigen to the muriatic, and forming the oxi-muriatic acid, which is used for *bleaching*, no doubt it will come into much more general use.

FOURTEENTH METAL.

—

COBALT.

THIS is a metal which has never yet been found pure in nature. It is met with generally in the state of an oxid, or alloyed with some other metals or combined with acids. In the state of an oxid, it forms the *black cobalt ore*, which is found in Germany in masses, or in the state of powder. Alloyed with other metals, it forms the *dull white cobalt ore*. United to sulphur and arsenic, it forms the *white cobalt ore*. And united to arsenic acid, it forms the *brown cobalt ore*.

To obtain cobalt in a state of purity, the ores containing it are roasted in the open fire, so that the sulphur and arsenic flies off. It is then found in the state of a black oxid. This is to be introduced in a retort with charcoal powder, and exposed to a most intense heat, until the metal is fused. It may be procured from the bottom of the vessel, when removed from the fire, in a tolerable state of purity. However it is commonly alloyed with iron.

Cobalt when in a pure state, is of a steel grey color, with a tinge of red, and a fine close grain. Its specific gravity is about 7.750. It requires a very intense heat to melt it. It may be readily broken and reduced to a powder. When heated in contact with air, it is oxided before fusion. It unites to metals, rendering them brittle; but its alloys are of no use. In its purest state, it is not only obedient to to the magnet, but according to Kahl and Wenzel, it can receive the magnetical power.

Cobalt, when oxided, unites to the acids, forming compounds, distinguished by the property of becoming green when heated. In consequence of this, they are used as *sympathetic inks.* A very good ink of this kind may be thus formed: Put into a vessel placed in a very warm situation one part of cobalt, and four of nitric acid, which must remain several hours, till the solution is completed. Then one part of common salt and sixteen parts of water are to be added. The solution is then to be filtered and kept for use. If letters be written on clean paper with this solution, they cannot be seen; but by exposing the paper to a gentle heat, the letters will appear of a fine green color, which will disappear when the paper cools, and again appear when heated. This change of color is supposed to arise from variations in the quantity of oxigen united to the metal, which depend on the heat.

Cobalt is obtained from the ores of Saxony, in the state of an oxid, forming the substance sold by the name *zaffer.* The zaffer of commerce is generally mixt with sand. Zaffer mixed with three parts of sand and one of potash, forms a blue glass, which when pounded in mills and included in casks, forms *smalt.* This smalt is agitated in casks filled with water, and pierced with three openings, at different heights. The water from the upper orifice brings out the lightest blue, which is called *azure of the first fire;* the heavier particles fall more speedily; and the azure brought out by the water of the three cocks, forms the different degrees of fineness, known under the names of azure of the first, second and third fire. Smalt is much used in the preparation of various cloths. The azures, when mixed with starch, form the *blues* commonly used by washing women. Glass is generally colored blue by this article, and also porcelain.

FIFTEENTH METAL.

—

NICKEL.

ABOUT 1750 this metal was first discovered. Generally it is found pure in the metallic state; sometimes it is combined with oxigen. Its ores have a coppery red color, covered more or less with a green powder. The most ore is that called *Kupfernickle*, in which the metal is united to sulphur, forming a sulphuret of nickel: and also some times with arsenic, cobalt, alumine, &c.

To obtain the metal pure, the ores should first be roasted to expel the sulphur and arsenic; it is then changed into a green oxid. This may be reduced to the metallic state by mixing it with charcoal and common salt, and exposing it to the strongest heat of a furnace. The metal then melts, and is found in the form of a button in the vessel.

Nickel, when pure, is of a pale flesh color. When fresh broken it has considerable lustre. Its texture is compact, and can be a little flattened by the hammer, as cast iron. Its specific gravity is 7.380. It requires a very intense heat for fusion. It unites to other metals, forming alloys of no value. Its attraction for iron is considerable, and but a small quantity renders it *magnetic*. It readily unites when heated in open vessels, to oxigen, forming a green oxid. The oxid unites to the acids, forming compounds of no importance. Its oxides are used to give a hyacinth color to glass.

SIXTEENTH METAL.

—

MOLYBDENA.

THIS metal is found but in small quantities. It has been found in Sweden, Germany, near the Alps, and in the island of Lemis, about Scotland. It is only found in combination with sulphur, forming the ore called *sulphuret of molybdena*, which resembles so strikingly plumbago or black lead, that they were long considered as varieties of the same species.

To obtain the metal pure is very difficult. The method recommended is as follows : Heat the ore for the sublimation of the sulphur, then powder the remaining part ; mix it with oil and expose it to an intense heat in a retort. By this means the metal may be obtained in the state of a powder, brittle under the finger, and possessing some lustre. Its specific gravity is about 7.000. It is one of the most infusible metals. It has a very strong attraction for oxigen, and unites to it in such quantities as to form an acid, called the *molybdic acid*. This, and no other preparation of the metal is found of use.

SEVENTEENTH METAL.

—

TUNGSTEN.

THIS metal has only been found in small quantities, in France, Spain, Britain, Sweden and Germany. Hitherto it has only been found united to oxigen, forming an oxid, and also an acid combined with lime. The first ore is called *wolfram*, and the other *tungstate of lime*.

To obtain the metal in a state of purity, its ores are to be intensely heated with charcoal and potash, but it is very doubtful if the metal has been procured free from mixture. The metal which chemists have been able to obtain from the ores of tungsten, is of a steel grey color It is very heavy. Its specific gravity being 17.06. It is one of the hardest metals, but is very brittle, and is as infusible as platina. It combines with sulphur, copper, iron, lead, &c. forming compounds which have not been examined with any care. It has a strong attraction for oxigen, and unites with such quantities as to be converted into an acid, called the tungstic acid. Neither this or its combinations have been found of service. It is, however, supposed that it may become useful in the arts of dyeing, as the color it gives to other substances cannot be destroyed by the oxi-muriatic acid, the destroyer of all vegetable dyes.

EIGHTEENTH METAL.

URANIUM.

THIS metal was discovered by Klaproth in 1789. It exists combined with sulphur and a portion of iron, lead and silex, in the mineral termed *pechblende*. Combined with the carbonic acid, it forms the *chalcolite*, or green mica. The ores are of a dark color, inclining to an iron grey.

and possessing a little lustre. They are found in the mines of Saxony and France.

To obtain the metal, the *pechblende* is first freed from sulphur by heat, and the oxid which remains is to be dissolved in nitric acid, and then precipitated by an alkali. The yellow oxid falls down, which must be mixed with oil and exposed to a strong heat.

Uranium appears as if it was composed of small metallic globules, connected slightly together. It is of a deep grey color. It is very porous and soft, has but little lustre, its specific gravity is 6.440. It is more difficult to be melted than manganese. It has been combined but with few metals, and has not been found of any value.

NINETEENTH METAL.

—

TITANIUM.

THIS metal has been but lately discovered. It exists in a state of combination, in but small quantities. It has been found in the ore named *menachanite*, combined with oxigen and iron; and also in the *red schorl of Hungary*, which is of a brownish red color.

It is difficult to obtain the metal pure. For the purpose, it is advised to melt one part of the oxid of Titanium, with six of potash, which is then to be dissolved in water. A white precipitate will appear, which is to be mixed with oil and charcoal, and exposed to a strong heat in a retort for several hours. The metal will then be had, of a reddish yellow color and very brittle. Its specific gravity is about 4.2. In a very intense heat it is volatilized. It has been applied to no use hitherto, in a free or combined state.

TWENTIETH METAL.

TELLURIUM.

THIS metal has been discovered since 1796. It is found in a state of combination with oxigen, gold, silver, copper and sulphur. It exists but in small quantities; and has been found only in the mountains of Transylvania. The ores containing it are named as follows :

1 Native Tellurium,
2 Graphie ore,
3 White ore,
4 Foliated ore.

When the metal is purified, its specific gravity is 6.110. It is as fusible as tin, and very volatile. When burnt, it smells like raddishes It has been united to several other metals, but has not been found of use.

TWENTY-FIRST METAL.

—

CHROME.

THIS is also a new metal, and is found but in small quantities, in the *red lead ore of Siberia*, in the *emerald* of Peru, and it has also been found in a state of combination in the department of the Var in France, forming the ore called the *chromate of iron*.

This metal gives a very bright color to the substances containing it. It has a remarkably strong attraction for oxigen, with which it unites, forming the *chromic acid*, which is of a beautiful ruby red color. This acid combines with other substances, forming compounds distinguished by the brilliancy of their color. By heating the acid with charcoal, it may be decomposed and the metal had pure, in the form of small masses of a white color iuclining to yellow. It has not been much examined; but from what is known, it may be useful, it is probable to painters and enamellers.

TWENTY-SECOND METAL.

—

COLUMBIUM.

THIS metal was only discovered in 1802 by Mr. Hatchett, who received the mineral containing it from a mine in Massachusetts. Nothing is known concerning this metal, excepting that it unites to oxigen in sufficient quantities to form an acid called the *columbic acid.*

Besides the twenty-two metals we have considered, there is another called *tantalium* which has been found in a small quantity in Finland. It has been procured from the minerals called *tantalite* and *yttro tantalite.* Nothing is known of it of consequence; and it is likely that it, as well as several of the last metals we have named, will hereafter be shewn to be compounds. It will readily be perceived that the metals existing in greatest quantities, and most useful, are among those first described, and that iron, manganese, gold, silver, lead, mercury and copper, are found in the proportion to the other metallic bodies, as silex, alumine and lime, are to the other earths.

Upon the whole, however, it must appear, from a survey of what has been stated, that this globe of ours is composed of forty-six substances, which are to be considered as elements: To wit;

4 *Unconfinable bodies.*

1 Heat or caloric.
2 Light.
3 Electricity.
4 Galvanism.

1 *Substance remarkable for causing acidity and combustion.*

1 Oxigen.

---

5 *Carried forward.*

5 *Brought forward.*

8 *Substances remarkable for the compounds they form with oxigen.*

1 Nitrogen,
2 Hidrogen,
3 Carbon,
4 Phosphorus,
5 Sulphur,
6 Muriatic acid or its base,
7 Fluoric acid or its base,
8 Boracic acid or its base.

2 *Substances called alkalies.*

1 Potash,
2 Soda.

9 *Earths.*

1 Silex,
2 Alumine,
3 Lime,
4 Magnesia,
5 Barytes,
6 Strontites,
7 Zircone,
8 Glucine,
9 Yttria.

22 *Metals.*

1 Mercury,
2 Platina,

46 *Carried forward.*

46 *Brought forward.*

3 Gold,
4 Silver,
5 Copper,
6 Iron,
7 Tin,
8 Lead,
9 Zinc,
10 Bismuth,
11 Antimony,
12 Arsenic,
13 Manganese,
14 Cobalt,
15 Nickel,
16 Molybdena,
17 Tungsten,
18 Uranium,
19 Titanium,
20 Tellurium,
21 Chrome,
22 Columbium.

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46 *Elements.*

On taking a survey of what has been advanced concerning these elementary bodies, we must be forcibly struck with the importance of oxigen, and the propriety of naming the compounds, as is done in the new nomenclature. Without oxigen the number of compounds would be very much diminished. The following, it may not be amiss to recapitulate.

Oxigen unites to most of the elements in different proportions; and according to the quantity of the oxigen is the nature of the compound formed. When it unites but in small quantities, it forms compounds, distinguised by the term oxid. Hence we have, the

Oxid of Nitrogen air,
Do. of Carbon
Do. of Sulphur
Do. of Mercury
Do. of Platina
Do. of Gold
Do. of Silver
Do. of Copper
Do. of Iron
Do. of Tin
Do. of Lead
Do. of Zinc
Do. of Bismuth
Do. of Antimony
Do. of Arsenic
Do. of Manganese
Do. of Cobalt
Do. of Nickel
Do. of Molybdena
Do. of Tungsten
Do. of Uranium
Do. of Titanium
Do. of Chrome, and
Do. of Columbium.

But besides the above twenty-five oxids, we have several others. It is found that oxigen unites, in some cases, to the same metal, in different proportions; so as to change very much the nature of the oxid. In consequence of this, these oxids are distinguished from each other by their color.---

Hence, we have the black and the red oxid of iron; the grey and the red oxid of tin, and so on.

When several substances are saturated, with oxigen, their properties are still more changed; and they are converted into the compounds called acids, the properties of which we considered when treating of oxigen. In consequence of this we have 12 acids; which are named according to the names of their *bases*, or the substances uniting to oxigen, to wit:

1	Nitric	acid,
2	Carbonic	do.
3	Phosphoric	do.
4	Sulphuric	do.
5	Mariatic	do.
6	Fluoric	do.
7	Boracic	do.
8	Arsenic	do.
9	Molybdic	do.
10	Tungstic	do.
11	Chromic	do.
12	Columbic	do.

On further examination we find that the strength of these acids is found to differ considerably. This arises from their not being fully combined with oxigen: yet they still possess the properties of acids. Now to distinguish these acids from the above, they are named on the same principle, but the termination of the name is made to vary from *ic* to *ous*. In consequence of this we have the three following acids, to wit:

1	Nitrous	acid,
2	Phosphorus	do.
3	Sulphureous	do.

Besides these acids, we have one more formed by the addition of oxigen to the muriatic acid, called oxi-muriatic acid : making in the whole 16 acids, formed by the union of oxigen with simple substances.

These various acids are most remarkable for uniting to the akalies, earths, and metallic oxids, forming compounds, called *neutral salts;* of course, the number of neutral salts must appear very great. However, some of the acids do not unite to some of the other bodies. To distinguish these salts from each other, names have been we find, very judiciously selected from the names of the acids, and those of the bodies to which they unite. The termination of the name of the acid is only a little varied. When the acid is perfect, and its name ends in *ic*, this is only changed into *ate;* and when it ends in *ous*, this is changed into *ite*. Now, for example, the nitric acid, unites to potash; forming a neutral salt, which should be called *nitrate of potash:* and the same with the rest of the bodies; so that we have the nitrate of soda, of ammonia, of lime, of mercury, &c. &c. When the phosphoric, sulphuric, or any other acids are used, we have the *phosphate*, *sulphate*, *carbonate*, *muriate*, &c. of potash, of soda, of ammonia, of lime, and so on, of the the rest of the bodies capable of uniting to the acids.

When the weaker acids are used, then the names are changed. The name of the acid as above ends in *ous*, and this being changed to *ite*, we have the names of nitrite, and sulphite. The compounds these form are therefore called,

Nitrite of Soda,
Do. of Potash,
Do. of Ammonia,
Do. of Lime,

And so on, with the phosphorus and sulphureous acids, with the other bodies to which they unite. But these neutral salts as well as most of those formed by the stronger acids, are found of no manner of use.

But the above are not the only kind of combinations.--- Many of the elements unite to each other forming compounds, without the aid of oxigen. These compounds are named, however, on the same principles.

Carbon, sulphur and phosphorus, particularly, are found to unite with several other elements. In this case, when the compounds are formed of carbon and other bodies, they are called *carburets*. Hence we have the *carburet of iron*, or steel, and perhaps some other compounds. When sulphur is used, the compounds are called *sulphurets:* Hence we have the

Sulphuret of potash, or liver of sulphur,
----------- of soda,
----------- of lime,
----------- of iron,
----------- of copper,

and so on with the rest. When the bodies are united to phosphorus, then they are called *phosphurets*. Hence we have the *phosphuret of lime*, of iron, and so on with the rest.

The last combinations we have to notice, are called *alloys*. These are formed as is known already, by the union of the metals with each other.

From the above short sketch, the advantages of the new nomenclature must appear very evident. How could any one know the constituents of one hundredth part of the many compounds which may be formed, unless the name give him some idea of the constituents? Indeed it seems astonishing, that this method of naming these compounds had not been earlier adopted. It is founded on principles which are put in practice every day by the youngest minds. We constantly hear persons in speaking of objects, give some idea of their composition. Hence we hear of a *stone*, of a *brick*, of a *wooden*, of a *mud*, and of a *straw* house; which are names just as remarkable, and designed for precisely the same purpose as the *sulphate*, *muriate*, *nitrate* and *carbonate* of soda, or of any other substance.

DISCOURSE IX.

HAVING now given some idea of all the elementary substances which have been found in nature, and having only glanced at some of the remarkable compounds met with in the mineral kingdom, it will be proper here to dwell more particularly on the most important of them, by which their qualities will be better understood, and more correct notions of the relative importance of each elementary substance will be formed. And first, concerning the waters which contain bodies in solution. All these may be classed under the head of

MINERAL WATERS.

WHILE considering water, it was stated that its power of dissolving many substances was very remarkable; and that when it had been united to such in sufficient quantities as changed its sensible properties, it was termed mineral water. The properties of mineral waters depend on the particular substance held in solution in the water; and the water is generally designated by the name of the mineral held in solution.

But few waters more forcibly claim our attention than those of the ocean, which every one knows contain great quantities of saline substances, particularly common salt. Indeed, if the sea were not impregnated with these saline bodies, the putrefaction of the immense mass of animal and vegetable matter which it contains, would shortly prove fatal to all living animals.

The absolute quantity of sea water cannot be ascertained, as the mean depth of the sea is unknown. According to the calculations of Mr. de la Place, it must be at least four leagues. Even on the supposition that its mean depth is not greater than the fourth of a mile, its solid contents (allowing its surface to be three fourths of that of the superficies of the earth) would be 32,058,939 cubic miles.

Sea water has a very disagreeable bitter taste, at least when taken from the surface, or near the shore; but when brought up from great depths, it is only saline. Hence we learn, that this bitterness is owing to the animal and vegetable bodies with which it is mixed near the surface. Its specific gravity varies from 1.0269 to 1.0285. It does not freeze till cooled down to 28°

By a number of experiments made by different chemists, it has been ascertained that sea water holds in solution muriate of soda, or common salt, sulphate of magnesia and sulphate of lime besides the animal and vegetable bodies with which it is occasionally contaminated. The average quantity of saline ingredients is one twenty-eighth. It was found that water taken up from 60 fathoms, near the Canaries, contained about one twenty-fourth. One hundred parts of this when analyzed was found to contain

30.911 common salt,
6.222 muriate of magnesia,
1.000 sulphate of lime or plaster of Paris.

Mr. Lavoisier found 10,000 parts of sea water, taken up on the west of the Dieppe, to contain the following salts:

1375 common salt,
256 muriate of lime and magnesia,
156 muriate of magnesia,
87 lime,
84 sulphate of soda and magnesia.

1958

or almost one fifth of saline contents; but this proportion is undoubtedly excessive.

The common ocean is found to contain most salt about the equator, and some degrees towards the south of it.--- The quantity is less in nothern latitudes. The proportion also at different times is found to vary. In the Baltic, when an east wind prevails, only $\frac{1}{108}$ of the water is saline; but this proportion is doubled by a westerly storm: The Euxine and Caspian seas, are stated to contain less salt than the ocean; but it is probable that the Mediterranean is as salt as the Atlantic.

The water of the *Dead sea*, differs exceedingly from sea water. Its specific gravity is 1.2430, and it is saturated with salt, containing no less than 44.4 per cent. of saline matter: according to the analysis of Lavoisier, it is composed of

55	: 60	water,
38	: 15	muriate of lime and magnesia,
6	: 25	common salt,
100	000	

Some remarkable cases have occurred, in which the use of sea water as a medicine, in doses of half a pint a day, proved of great service to valetudinarians. Bathing in this water, has also been found beneficial. The salts it contains, serve to stimulate the skin, and thereby prove strengthening to the whole system.

BUT the appellation of *mineral waters*, is generally confined to such as are obtained from springs, impregnated with substances, giving them some peculiar smell, taste, color, &c. Many of these springs attracted the attention of mankind in the earliest ages; and were resorted to by those who labored under diseases. But it has only been since the middle of the 17th century, that attempts were made to discover the ingredients of which these waters were composed, or to discover the substances to which they owe their properties.

The substances found in mineral waters, are so numerous, and some of them exist in such small quantities, that it will be proper to dwell only on those which are most remarkable. These are the waters which contain airs, the sulphuric acid, and several neutral salts.

The different aerial fluids, ought to be first separated and examined. For this purpose a retort ought to be filled two thirds with the water, and connected properly with a pneumatic tub filled with mercury. The water should be made to boil for a quarter of an hour, and the airs will pass over into the jar. When the apparatus is cool, the quantity of air expelled from the water will be seen, and allowances should be made for the air of the retort.

The only airs found in water are, atmospheric, oxigen, nitrogen, carbonic acid, sulphurated hidrogen, and sulphureous acid airs. The last two never exist in the water together. Having procured the airs, they should then be examined by chemical tests. The quantity of oxigen may be determined on by burning phosphorus in it. The quantity of carbonic acid will be known, by agitating it over lime water. The presence of the sulphureous acid may be known, by its being partially soluble in water, to which it gives the properties of an acid. Or if potash be added to the water, the acid is more readily absorbed, and a *sulphite of potash* is formed. If sulphurated hidrogen be present, it will burn in contact with oxigen, and the products will be water and sulphuric acid, as may be noticed. The remaining air, it may safely be concluded, is nitrogen air.

Atmospheric air is contained in by far the greater number of mineral waters; its proportion does not exceed one twenty-eighth of the bulk of the water.

Oxigen air was first detected in waters by Scheele. Its quantity is usually inconsiderable; and it does not exist in them when sulphurated hidrogen air is present.

Nitrogen air was first discovered in Buxton water by Dr. Pearson of England ; it has since been detected in those of Harrogate, and in those of Limington Priars.

Carbonic acid was first discovered in Pyrmont water by Dr. Brownrigg. It is the most common ingredient in mineral waters, 100 parts of it generally containing from 6 to 40 parts of this air. It gives to them a sparkling appearance like Champaigne wine. They are taken as tonic medicines.

Sulphureous acid has been observed in several of the hot mineral waters in Italy near volcanoes. Some of the waters of this country contain it, and they are drank for their strengthening virtues.

Sulphurated hidrogen air, constitutes the most conspicuous ingredient in these waters which are distinguished by the name of *hepatic* or sulphureous. They have a disagreeable smell, by which they are characterized.

The presence of sulphuric acid may be readily detected in water, by adding barytes water. The barytes unites to the acid forming an insoluble compound, which should be separated. One hundred grains of this compound contain 23.5 of real sulphuric acid.

The neutral salts commonly met with, are as follows :

Sulphate of soda, or Glauber's salts. This is not uncommon, especially in those mineral waters which are distinguished by the term *saline*. They possess a purgative property when taken in large quantities. The quantity of this salt may be ascertained by evaporating the water.

Sulphate of lime, or plaster of Paris, is found in small quantities very generally in water.

Sulphate of magnesia, or Epsom salt, is almost constantly an ingredient in such waters as have purgative powers. It was detected in Epsom water in 1610.

Sulphate of alumine, or alum, is occasionally met with. It may be detected by adding carbonate of lime, or magnesia. These various *sulphates* may all be precipitated from the waters containing them, by adding pure ardent spirit for which the water has a stronger affinity than it has for these compounds.

Nitre has been occasionally met with. It may be detected by partly evaporating the water and then on wetting and drying the paper it burns in a manner which indicates the presence of nitre. Dr. Woodhouse found it in considerable quantities in the pump waters of Philadelphia.

Muriate of soda, or common salt, is so very common in mineral waters, that scarcely a spring is found without it.

Sulphate of iron, is also frequently met with in mineral waters, and also the *carbonate of iron*. The waters containing iron may readily be known by adding the prussic acid to them which renders them of a blue appearance, or by adding a decoction of galls, which renders them black. When the carbonic acid is united to iron, on heating the water, the acid escapes and the iron falls to the bottom in the state of an oxid. The water containing iron (called chalybeate waters) are very generally drank as a tonic medicine. They may be formed at any time, as must readily appear, by art; nothing more being necessary than to add the iron in the state of an oxid, to the water which has the acid to be dissolved in it.

For the particular means of detecting the exact quantities of substances in mineral waters, I must refer to a treatise on this subject by Mr. Kirwan. And Dr. Saunders has published an exact account of the virtues and constituents of the most celebrated springs. I shall therefore conclude this subject with the following statement, which will lessen the trouble of analyzing water, as the compounds in the first columns can never exist in considerable quantities in water with those in the second.

Salts	incompatible with
Sulphates of the alkalies,	nitrates of lime and magnesia, muriates of do. &c.
Sulphate of lime,	alkalies, carbonate of magnesia, muriate of barytes.
Alum (sulphate of alu.)	alkalies, muriate of barytes, nitrate, mu. and car. of lime, carbonate of magnesia.
Sulphate of magnesia,	alkalies, muriate of barytes, nitrate and muriate of lime.
Sulphate of iron,	alkalies, muriate of barytes, earthy carbonates.
Muriate of barytes,	sulphates, alkaline carbonates, earthy carbonates.

Salts	incompatible with
Muriate of lime,	sulphates, except of lime, alkaline carbonates, carbonate of magnesia.
Muriate of magnesia,	alkaline carbonates, alkaline sulphates.
Nitrate of lime,	alkaline carbonates, carbonates of magnesia and alu. sulphates, except of lime.

WE now come to the consideration of that part of chemistry, termed MINERALOGY; as it has for its object the description of the solids of the globe, all of which are known by the term *minerals*. These substances, without doubt, must have at all times attracted the attention of mankind; because from them alone are drawn the metals, stones, and other similar bodies of indispensable use. But it is only very lately, that the method of ascertaining the component parts of these substances was discovered, or that it was possible to describe them, so as to be intelligible to others.

Mineralogy, as far as it is a chemical science, includes under it three different topics; namely, an account of the properties and constituents of minerals, an account of the various combinations these bodies form, and the art of analyzing them.

The description of minerals occupy a very conspicuous part of the works on mineralogy; and to favor this purpose mineralogists have invented a language of their own, by which they can readily give an idea of the external characters of bodies. But as it is not consistent with the nature of this undertaking to enter so minutely into the consideration of such particulars, we must refer to the works expressly written on the subject by Werner, Kirwan and others. Our attention will chiefly be confined to some remarkable substances, which have a strong claim for consideration.

In detecting the chemical properties of minerals the blow pipe will be of singular use, as it enables us in a few minutes to determine many points which by the usual processes would occupy a great deal of time. The blow pipe is merely a tube, ending in a cavity as small as a fine wire, through which air is forced and made to play upon the flame of a candle, by means of which the flame is concentrated and directed against small particles of the mineral to be examined, either placed upon a bit of charcoal, or in a spoon of silver or platina. The air is either forced into the blow pipe by the lungs of the experimenter, or by means of bellows attached to the blow pipe. By thus exposing a very small portion of a mineral to the concentrated flame, we see the effect of heat upon it, and have an opportunity of trying the action of other bodies on it, at a very high temperature, as of borax, soda, &c. The properties which these experiments bring into view, enable us, in many cases, to ascertain the nature, and even the component parts of a mineral, particularly such as are metallic.

Mineralogists have very generally divided the mineral kingdom into four classes:

1 Stones,
2 Salts,
3 Combustibles,
4 Ores.

The first class comprehends all the minerals which are composed chiefly of earths: The second all the combinations of acids and alkalies which occur in the mineral kingdom: The third those minerals which are capable of combustion, and which consist chiefly of sulphur, carbon and oil: The fourth, the mineral bodies which are composed chiefly of the metals.

OF STONES.

THE great class of stones are arranged by the mineralogists under the heads of the elementary earths; each stone being considered as belonging to that kind of which it is chiefly composed. Hence, all the stones are to be numbered under the following heads.

1 Silicious,
2 Aluminous,
3 Calcareous, (or of the nature of lime)
4 Magnesian,
5 Barytic,
6 Strontitian,
7 Jargonian,
8 Glucinian,
9 Yttrian.

However, a little consideration will be sufficient to discover that there is no foundation for these divisions. Most stones are composed of two, three, and sometimes four ingredients: and in many cases, the proportion of two or more is nearly equal. It is not consistent with the plan of this work, to enter into the consideration of the particular stones met with in nature. The means of analysing them, and determining to which species they belong, may be understood from what was said while considering each elementary earth.

Before this analysis is commenced, the mineral should be reduced to a very fine powder. This is by no means an easy task when the stone is extremely hard. It ought to be raised to a bright red heat in a crucible, and then instantly thrown into cold water. This sudden transition makes it crack and break to pieces. If these pieces be not sufficiently small, the operation must be repeated on each, till they are reduced to the proper size. These fragments are then to be beaten to small pieces in a polished steel mortar; when the examination may be commenced with.

OF SALTS.

THE number of salts met with in the mineral kingdom, is not numerous. They are named according to the names of the acids and bases to which they are united. The method of analysing them may be understood from what was said concerning the particular acids and substances for which they have the strongest affinity.

OF COMBUSTIBLES.

THE combustible substances belonging to the mineral kingdom, excluding the metals, are all included under the following heads.

1 Sulphur,
2 Diamond,
3 Bitumen,
4 Pit Coal,
5 Amber,
6 Plumbago.

I. SULPHUR.

SULPHUR is frequently found in many parts of the world, particulary about volcanoes, as Hecla, Etna, Vesuvius, the Lipari Islands, &c. It is either in the state of powder or crystallized. It may be distinguished by its color, smell, combustion, &c. It may be separated from the substances with which it is blended, by means of heat, as it readily melts and may be made to sublime.

II. DIAMOND.

OF this enough was stated while considering it under the head of çarbon.

III. BITUMEN.

BY bitumen is understood, by mineralogists in general, an oil which is found in different parts of the earth, in various states of consistence. These different states form different species, which have been arranged as follows.

NAPTHA.

THIS is found sometimes on the surface of the water of springs, and sometimes issuing from certain spots. It is fluid and trsnsparent; of a white or yellow color; strong, but not disagreeable smell; feels greasy; burns very readily with a white flame and leaves scarcely any thing behind. It is not soluble in alcohol. When exposed to the air, it becomes yellow, and then brown. Its consistence increases, and finally it passes into

PETROLEUM.

THIS substance is found in Persia, and likewise in many countries in Europe, particularly, Italy, France, Switzerland, Germany, Sweden, England, and Scotland. It is not so fluid or transparent as water. Its color is yellow, either pale or with a shade of red or green; reddish brown and reddish black. Its smell is less pleasant than that of Naptha. When burned, it yields a soot, and leaves a little coal behind. By exposure to the air, it becomes like tar, and is then called

MINERAL TAR.

THIS substance is found in many parts of Asia, America, and Europe. Its consistence is thick; of a black, brownish-black, or reddish color; smell sometimes strong, but often faint. When burned, it emits a disagreeable smell. By exposure to air it passess into

MINERAL PITCH AND MALTHA.

THIS has a strong resemblance to common pitch. In warm weather it is soft, and is then called *adhesive mineral pitch*. When the weather is cold, it is brittle; and when broken, has a glassy lustre. In this state it is called *maltha*. Color, black, dark brown or reddish. In a high heat it burns and leaves a quantity of grey ashes. When it is further hardened, it passes into

ASPHALT.

ASPHALT is found abundantly in many parts of Europe, Asia, and America, especially in the island of Trinidad. Its color is black, or brownish black. It feels smooth but not greasy. Does not stain the fingers; and has no smell unless rubbed or heated. When heated, it melts and burns almost entirely away. This article is manufactured in France, and is used for greasing the wheels of carriages.

ELASTIC BITUMEN.

THIS substance was found about the year 1786, in a mine in England. Its color is either yellow, reddish, or blackish brown. In appearance, it has a strong resemblance to elastic gum, or Indian rubber: hence its name. Its consistence varies. Sometimes it is so soft as to adhere to the fingers; sometimes it is as hard as asphalt. When soft, it is elastic; when hard it is brittle. It is insoluble in alcohol, oil of turpentine: but it is soluble in oil of olives. When distilled, an oil comes over, and the residuum is carbon. There is a variety of it, strikingly like common cork when fresh cut; but in a few days after being exposed to the air, it becomes of a pale reddish brown. This substance seems to be the elastic bitumen, altered in its texture by water.

IV. PIT COAL.

THE substances belonging to this head, are composed chiefly of bitumen, and carbon, existing in the state of an oxid or *charcoal.*

JET.

THIS substance is found in France, Spain, Germany, England, and other countries. It is found in detached kidney form masses of various sizes, from an inch to 7 or 8 feet in length.

Its color is full black; it has considerable lustre when broken; it has no odour unless heated. It melts in a strong heat, burns of a greenish flame, and leaves an earthy residuum. By friction it becomes electric; and when distilled it yields a peculiar acid.

This mineral is formed into buttons, beads, and other trinkets, in France, where its manufacture is chiefly confined.

CANAL COAL.

—

THIS mineral is found in Lancashire, and in different parts of Scotland, where it is known by the name of *parrot coal.* Its color is black; its structure sometimes flaty; it is brittle, and does not stain the fingers. It kindles easily, and burns with a bright white flame like a candle, which lasts but a short time. It is susceptible of a good polish, and is frequently wrought into trinkets. A specimen of it when analyzed was found to contain

75 : 20	charcoal,
21 : 68	maltha,
3 : 10.	alumine and silex.
99 : 98.	

COMMON COAL.

—

THIS very valuable combustible is found in great abundance in many parts. Its color is black, more or less, perfect, Its structure, more or less, slaty. It usually stains the fingers. It takes fire more slowly, and burns longer than the last species. It cakes more or less during combustion. Its combustion in the common way is, however, very imperfect. A considerable quantity of the carbon is carried off in the form of smoke, or falls to the bottom of the grates, in which it is burnt. This inconvenience may be readily avoided if the coal be previously reduced to a fine powder, and then wetted up with one third or one half of common clay, and then made into small cakes and dried. These cakes burn with great readiness, and throw out much heat, as the combustible matter being in a state of division, more readily unites to the oxigen of the air, forming fixed air, which escapes without *smoke*. It has been ascertained by the experience of many that it is of great advantage to have coal mixed as above with clay; and that these advantages are far greater than the trouble of making the mixture.

Of this species of coal, there are several varieties found in mines of various countries. They are distinguished by the names of caking coal, rock coal, &c. When analyzed, they are usually found to contain from 50 to 80 parts in the hundred of charcoal. The bitumen *maltha*, is found in them generally in small quantities; also, sulphur, and from one to six parts of earths.

In some species of this coal, the bitumen maltha is found in considerable quantities. In consequence of this it has been proposed to separate it by means of heat, and apply it in cases where pitch made of common tar cannot be procured. At one time the expectations in favor of its proving of value were considerable; but these have lessened very much, in consequence of its application, particularly to the bottom of ships, proving of no service after a few months.

The quantity of sulphur found is also considerable in some instances. This coal emits a sulphureous smell while burning, which is so disagreeable, that the value of the coal is much lessened. In general the purity or excellence of the coal may be judged of by its containing least sulphur, and greatest quantities of *charcoal*, which is *carbon oxided*, in which state it burns readily.

This species of coal, when reduced to a fine powder, is a most excellent manure. A number have tried it some years since; but have not derived all the benefit it is capable of affording, in consequence of not reducing it to a powder sufficiently fine. From experiments which I have made, in which I took such care to destroy the cohesion of the coal, so as to have it in the state of the finest flour, it appears that the coal is the very best manure which is used. Indeed if its cohesion be sufficiently destroyed, *it cannot be otherwise*; for the carbon it contains, is the chief constituent of plants, and they *must* unite to it while growing.

Immense mines of this coal are met with in this country. Near Richmond, in Virginia, it is found in great quantities, and of excellent quality. And on the banks of the Potomac, some hundred miles above the city of Washington, inexhaustible mines of it, of equal value, are met with. In taking a view of the extent and importance of these mines, on the Potomac, it is impossible to feel otherwise than forcibly struck with the providence of the Creator! We perceive the certainty with which the seat of the federal government has been the favored spot of a benevolent God, as well as a beloved Washington!

V. AMBER.

THIS substance, called *electrum* by the ancients, is found in different countries; but most abundantly in Prussia; either on the sea shore, or under ground at the depth of 120 feet. It is met with in lumps of different sizes.

It has a yellow color, considerable transparency, and becomes electric by friction. If a piece of it be affixed to the point of a knife and then kindled, it burns to the end without melting.

By distillation it yields an acid, called the *succinic acid*. This acid exists in a solid state; is soluble in twenty-four parts of cold and two of boiling water. It is slightly soluble in alcohol.

VI. PLUMBAGO.

OF this coal we also treated while considering carbon. It differs from commom coal in containing more carbon and iron. It is called also black lead.

THE composition of the various substances abounding with coal may be readily ascertained. When the coal is burnt, the ashes should be examined, by which a knowledge of the earths contained in the coal may be acquired. To ascertain the quantity of carbon, a given quantity of the coal should be heated in a retort, connected with a pneumatic tub; then the nitric acid, or common nitre, should be added to it, while an air comes over. The oxigen of the nitric acid unites to the carbon, forming carbonic acid, which escapes in the form of air: and in proportion to the quantity of this air is the quantity of carbon contained in the mineral experimented upon. By these means, the quantity of carbon in any soil may be ascertained.

By deducting the weight of the earths, and that of the carbon which united to the oxigen, forming carbonic acid, an idea of the quantity of bitumen in the coal may be formed.

METALLIC ORES.

THIS class comprehends all the mineral bodies, composed either entirely of metals, or of which metals constitute the most considerable and important part. It is from the minerals belonging to this class that all metals are extracted; for this reason they have obtained the name of *ores*.

The various ores are arranged under 22 heads, which bear the names of the metals most remarkable in them. The method of analyzing them may be understood from what was said concerning each metal. For more particular accounts than I have given, I must refer to treatises expressly written on the subject. Mr. Kirwan's is generally read.

DISCOURSE X.

THE attention of the chemist is early attracted by the great variety of compounds obtained from *matter organized*, or in other words, the products formed by vegetable and animal parts. It is well known that these products vary in their qualities almost in an infinite degree ; scarcely any two of them are found possessed of precisely the same properties. This must excite very much our astonishment, when sensible that all these innumerable compounds are wonderfully formed, by the union of not 50 different substances. Our surprise must be still more excited, when it is considered, that but a small part of these few elements enter into the composition of animal and vegetable parts. By means of heat, all the variety of compounds may be reduced to the elementary state ; and it will be found that all vegetable parts are chiefly composed of carbon, oxigen, and hidrogen, and all animal parts of the same elements with nitrogen, phosphorus, and lime. Sulphur, the alkalies, iron, gold, manganese, and silex, are also discovered in their composition, but only in small quantities. Perhaps, latent heat, light, and electricity, have much greater influence than the last named elements.

As no advantages rusult from that decomposition of vegetable and animal parts by fire, by which they are restored to the elementry state, we will not enter particularly into the consideration of the means which have been pursued for the purpose. However, there is another kind of decomposition which these substances undergo, by which they are converted to certain states, in which they possess particular general properties. When changed into these states, they are called *proximate principles.* We will first consider the composition of vegetable bodies.

Although every plant has qualities different from other plants; and although different parts of the same plant have different properties, yet all these compounds may easily be reduced to a few states, in which they are alike. These are called the proximate principles. The proximate principles of vegetables, or the states to which they may all be reduced, do not exceed sixteen. When reduced to these states they are called as follows:

1 Wood, or ligneous fibre,
2 Acids,
3 Tannin,
4 Oils,
5 Gluten,
6 Fecula,
7 Indigo,
8 Sugar,
9 Gum,

10 Resin,
11 Extract,
12 Elastic gum,
13 Camphor,
14 Wax,
15 Bitter principle,
16 Narcotic principle.

These will be treated of in the order in which they are named.

WOOD;

OR

LIGNEOUS FIBRE.

THIS forms chiefly the solid parts of vegetables, particularly of trees. It consists of a number of small fibres longitudinally arranged, and it supports and acts as a reservoir for the fluids of the vegetable. It may be exhibited pure, if shavings of wood be repeatedly boiled in water and ardent spirit. It will be found insoluble, of a white color, and combustible. It contains a little oxigen and hidrogen, with which however it parts, if heated in a close vessel, and there remains behind the carbon, of which it was formed, which retains the shape of the original mass. Carbon is therefore its chief constituent. This woody matter exists in greatest quantities in black ash, common oak, guaiacum, hickory, &c. It is very remarkable for resisting putrefaction. For years, and almost centuries, it sometimes remains without decaying. The time in which wood resists decomposition, depends very much on its state of purity. The substances or juices of the tree with which the wood is blended, tend very much to hasten its decay. Hence, by exposing logs to heat, which evaporates the fluid parts, their duration is protracted. On this is founded the practice of burning or *charring* posts introduced in the earth. The advantages derived from the evaporation of such fluids, are clearly shewn by the longer time which logs remain that have been sawed through, than those not opened. Judge Peters of Philadelphia has published a most valuable paper on this subject, in which he clearly shews the impropriety of painting green wood; as the paints prevent the extrication of the volatile parts within. In a conversation I had with the venerable and hospitable Mr. Henderson of Dumfries, Virginia, he stated that the advantages derived from having timber from trees sawed through, or split open through the middle, were very surprising. Fifty years ago this wealthy gentleman had a house built in Colchester, of logs divided longitudinally through the heart; and they retain their original firmness at this day; while those built in the neighborhood without this division of the timber, have long since decayed. It has also been found that logs last longer after they remain some time under water. No doubt but the water acts as a preservative by dissolving and carrying off parts of the wood disposed to decay. The common notion is that it carries off an *acid*. It appears to me, as the solvent power of water is much increased by heat, that in parts where it is a great object to have timbers to remain long, considerable good might be derived by *boiling the logs*, in a large contrivance for the purpose, before using them.

II. ACIDS.

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IN various states of combination in a great variety of plants, we find juices remarkable for exciting the sensation of *sourness*. This arises from the acids they contain. These acids when particularly examined, are found to be but seven in number, and diffused in different states of combination. They are called *native vegetable acids*, and are named, the

Citric,
Malic,
Oxalic,
Gallic,
Benzoic,
Tartareous, and
Acetic acids.

These acids have for their bases, combinations of hidrogen and carbon, and owe their acidity to the oxigen they contain. In consequence of this, they may frequently be formed, and converted the one into the other by art. They all unite to the alkalies, earths, and oxids, forming compounds which are of very little known value, and consequently our remarks concerning the whole will be but few. The compounds are to be named as heretofore.

CITRIC ACID;

OR

ACID OF LEMONS.

—

THIS exists in the juice of lemons in the largest quantities. It is also found in oranges, unripe grapes, cranberries, bilberries and a variety of other sour fruits. It may be had in a state of purity by the following process. To 100 parts of boiling lemon juice, add about four parts of chalk: a precipitate will appear consisting of the citric acid and lime (citrate of lime) which must be separated and washed in water.--- Then add to it, about 20 parts of sulphuric acid, diluted with six times its weight of water, and boil the whole for an hour, agitating it during the whole time. The sulphuric acid unites to the lime, and the citric acid remains in the water; and if evaporated, it crystallizes. To be had pure, it must be dissolved and crystallized several times. This acid may long be preserved pure. It has a most delightful taste, when diluted with water; and hence it is used for punch. In a high heat it is decomposed and converted into carbonic acid; and carbonated hidrogen air, and a little charcoal remains.

MALIC ACID;

OR

ACID OF APPLES.

—

THIS acid is found in the juice of unripe apples; and in those of barberries, elderberries, gooseberries, plumbs, and the common house leek. To prepare it, take the sour juice of apples; saturate it with potash, and add the sugar of lead, while a precipitate appears. This is *malate of lead;* to which sulphuric acid should be added till the liquid is sour, without any mixture of sweetness. The malic acid will remain in the water, while the sulphuric is united to the lead. This acid can only be had in a fluid state. Its taste is an unpleasant sour; and it undergoes a decomposition when exposed to the air.

OXALIC ACID.

THIS acid is prepared only by art. In order to procure it, boil in a retort one part of white sugar, with four of nitric acid. When the fluid acquires a brown color, add two parts more of the acid, and continue the heat while the fumes arise; when the mixture cools the acid will crystallize. This acid contains more oxigen than any other vegetable acid. It is remarkable for its strong attraction for lime; which being superior to any other acid, it is used to detect the presence of lime in all its combinations. In a high heat it is decomposed into carbonic acid, and carbonated hidrogen air.

GALLIC ACID.

THIS acid exists in nut galls; in the husks of nuts; in oak bark; the persimmon tree; and in all those vegetables called astringents. The acid may be obtained pure by exposing powdered nut galls in a retort to a *moderate* heat. The acid by this means sublimes, and a part condenses in small white crystals in the necks of the retort.

This acid is sour and astringent, when dissolved in water: it strongly reddens blue vegetable colors. It sublimes in a gentle heat, but is decomposed in a higher temperature. It has a strong tendency to unite with metallic oxides. With the red oxid of iron, it is remarkable for producing a deep black precipitate, which is the basis of black ink and dyes. Hence it is a good test, by which the presence of iron may always be detected in any fluid.

A good ink may be prepared by digesting a strong infusion of galls over the red oxid of iron; to which, when black, a little gum arabic should be added. When the nut galls cannot be procured, the unripe juice of persimmons, or a decoction of oak bark will answer. The best ink, it is stated, is thus made: take two quarts of water; one ounce of rasped logwood, and two ounces of gum arabic, and boil them till half the water is evaporated. Then let the liquid be strained, and add to it three ounces of nut galls, 1 dram cloves, and one ounce of copperas (sulphate of iron): This should be stirred repeatedly, and preserved for use in stopt vessels. Writing with this and common inks may be effaced, by wetting the paper with the oxi-muriatic acid in water. It may however be restored, by putting the paper in a weak solution of the sulphuret of ammonia; and this will also restore the color of old writing. If indigo and the oxid of manganese be added to inks, they cannot be destroyed by the above acid. A little loaf sugar is sometimes added to give inks a shining appearance.

BENZOIC ACID.

THIS acid exists in considerable quantities in the resin called *benzoin*; in the balsams, in liquid storax, in glue, silk wool, sponge, mushrooms, &c. It may be obtained pure by exposing benzoin to a gentle heat, in a bason covered with blotting paper. The acid sublimes and adheres to the paper. This acid when pure is void of odour. Its taste is irritating, and it is not very soluble in cold water. It unites to other bodies forming benzoates, which have not been examined.

TARTAREOUS ACID.

THIS acid exists in the juices of grapes and many vegetables, most commonly in combination with potash and lime. It is obtained chiefly from grapes, in which it exists in combination with potash. The common *cream of tartar* of the shops is obtained from grapes, and is composed of this acid and potash. The acid may be had in a state of purity, by taking two pounds of cream of tartar---dissolve them in water, and add chalk as long as a precipitate appears. This precipitate is the *tartrite of lime*, which is to be put in a vessel with 9 ounces of sulphuric acid and 5 of water. After remaining 12 hours, with occasional stirring, the tartareous acid is set at liberty, and dissolved in the water. The solution may be evaporated and crystals of the acid will appear. This acid is exceedingly sour, is not altered by the air, and is very soluble in water. It has a strong tendency to unite to potash; and in combination with this alkali, it forms

CREAM OF TARTAR;

OR

ACIDULOUS TARTRITE OF POTASH.

THIS compound is obtained in great quantities from various wines while fermenting. It is deposited on the inner sides of casks in various quantities. The Hungarian wines afford smallest quantities; the wines of France yield more, but the Rhenish wines afford most. When taken from the sides of casks after they are opened, it is called crude tartar, and is red when obtained from red wines. To purify the tartar, it is dissolved in hot water, and suffered to crystallize after cooling. These crystals are again dissolved and crystallized, and are then sold under the name of *cream of tartar.* This compound has an acid taste in consequence of being fully saturated with potash. It is not very soluble in cold water. But if a little potash be added to saturate the excess of acid, it then becomes a pure *tartrite of potash*, and is much more soluble in water. The compound, called cream of tartar, should therefore be termed *acidulous tartrite of potash.* In some places this salt is used to season food, to make punch, and more generally, as a medicine, in doses of near an ounce.

ACETIC ACID,

OR

VINEGAR.

—

THIS acid exists in small quantities in cream of tartar, and in some other vegetable products. But it was obtained chiefly by the *acetous fermentation* of vegetable substances; and is the acid which gives the sourness to *vinegar*. Vinegar is formed very generally, by the fermentation of wine, cyder, beer, or any fluid which has undergone that fermentation called vinous, by which a substance termed *spirit*, possessed of an intoxicating quality is formed.

But it should be observed that this *spirit*, when in a pure state, or only diluted with water, will not undergo this acetous fermentation. Besides the presence of the spirit, there must be some extractive or mucilaginous matter present. Hence Mr. Chaptal long exposed *pure old wine* to the open air at a proper temperature, but it was not rendered sour. On adding, however, vine leaves to the same wine, and on adding other extractive matter to mixtures of spirit and water, they readily fermented. When such kind of matter is present in sufficient quantities to cause the process to commence, then the strength of the products is in proportion generally to the quantity of spirit in the fluid.

For this acetous fermentation to take place in such fluids, they should be placed in a warm situation, and the air should be allowed to have free access. When this is the case, the fermentation soon commences; the fluid appears muddy; its surface becomes covered with a muddy pellicle; the fluid loses its taste and odour; it becomes sour; a quantity of mucus matter is separated, and forms a kind of skin, which sinking down is vulgarly called *mother of vinegar;* oxigen is absorbed from the surrounding air; and the sourness increases till the process is ended; so that good vinegar is formed. Vinegar when fully fermented, is clear and nearly colorless; it has a pleasant odour and taste, and possesses all the properties of acids. When distilled the *acetic acid* to which it owes its properties, rises in the vessel and is condensed, constituting pure *acetic acid.* The quantity of this acid is in proportion to the strength of the vinegar.

Acetic acid is very volatile; its fumes are too strong to be agreeable; it acts as a caustic on animal matter; and it unites to the alkalies, earths and metallic oxids, forming compounds called *acetates*, most of which have not been examined. The most useful are the two named elsewhere; to wit, verdigris, or *acetate of copper*, and sugar of lead, or *acetate of lead.*

The acetic acid, under some circumstances, parts with a portion of its oxigen, and it then constitutes the acid called

ACETOUS ACID.

This is a colorless fluid, less active than the acetic acid, and contains less oxigen. Its smell is suffocating. It unites to the common bases of the acids, and forms compounds which have not been much examined. They are called *acetites.*

BESIDES the above seven acids, there are several of a similar kind, which are formed during the decomposition of some vegetable substances. Such are the acids called *pyro-mucous, pyro-ligneous, pyro-tartareous, the succinic, suberic and camphoric* acids. The first three are found to be the acetic acid, disguised with fetid oil.

SUCCINIC ACID.

THIS is obtained by the distillation of a bituminous substance, of a yellow color, called *amber*, which is found in some places. It exists in a solid form and has a strong acid taste. It is not much known.

SUBERIC AND CAMPHORIC ACIDS.

THE first is obtained by distilling nitric acid over cork, and the second by distilling the nitric acid over camphor. The acids have not been much examined. It is probable that these and many more, which might be formed by various combinations, are not worthy of attention.

III. TANNIN.

THIS is one of the constituents of vegetables, and was, until lately, confounded with the gallic acid. It is a substance of great importance, as it is only by it, that we are enabled to tan leather: hence its name. However, it is not met with in great quantities in the vegetable kingdom. Its most essential qualities are as follows: It has an astringent taste; is soluble in water and ardent spirit: it unites to animal jelly, forming an insoluble compound: with the salts of iron it forms a deep blue or black color. It may be obtained in a tolerable state of purity by adding powdered nutgalls to hot water; stirring the mixture for some time, and then pouring off and evaporating the decoction, by a slow fire. The tannin will then remain in the form of a dark mass. If small quantities of animal jelly, dissolved in much water, be added to the decoction containing the tannin, the two unite together, forming an insoluble compound, by which the quantity of tannin present may be judged of. However, if too much jelly be added, this compound will be dissolved by the jelly.

The largest quantities of tannin are contained in the Bombay catechu, and in nutgalls; but as these articles cannot be had in sufficient quantities for the purpose of tanning leather, it is usually procured from other vegetable substances; and particularly the inner bark of trees. Of the several trees containing it, the largest quantities are found in the barks of the Leicester, or Huntington willow, of the common oak, smooth oak, and of the Spanish chesnut. The barks of these trees are taken off in the spring, and then by mechanical contrivances are reduced to powder, in which state, they are put in vessels containing water with the hides of animals which are to be tanned.

The large and thick hides receive their color from the infusion of bark; after this part of the process is ended, it is common among tanners to put the hides into water slightly impregnated with sulphuric acid, or with the acid evolved during the fermentation of barley and rye. This renders them harder and fits them for forming sole leather. The tanners also put their small skins, designed for fine leather, in water, to which pigeon's dung which has not fermented, is added. This infusion is called the *grainer*, and it is stated that it renders the leather thinner, softer, and more proper of course for making upper leather. What real advantage is derived from these mixtures is not exactly ascertained. But it is certain that the processes of common tanners may be very much shortened. And instead of requiring from six months to two years to make leather, it can no doubt be done in a few weeks or days.

It was formerly supposed that the tanning of leather depended on the power of barks, to constringe together the fibres of the hides of animals. But this supposition is not correct. The new qualities of skins acquired by tanning, depend on the chemical union of the *tannin* of the barks with the animal *gelatine*, or jelly of the hide; (of which jelly great quantities exist in hides, as will appear by boiling them.) In consequence of having ascertained this truth, leather can now be tanned in a lesser number of days, than formerly required weeks; and perhaps in a lesser number of hours, without any increase of expense or labor.

The process for tanning leather, which Mr. Seguin of Paris has practised with great success, is the following. Instead of shaving the hair from skins, they are to be freed of it by means of lime; as the lime not only removes the hair, but destroys the outer covering of the skin, which only serves to impede the union between the tannin and jelly. To effect this, some slaked lime should be thrown in a pit of water, and well stirred: the hides should be kept in this lime water, which is repeatedly to be agitated for seven or eight days, when the hair may be removed with facility. This being done, the hides are, as tanners term it, to be *raised*, or swelled. For this, they are to be introduced in water, one thousandth part of which is sulphuric acid, and kept in it about two days. They now acquire a yellow color, even in their interior, as may be seen by cutting them. This being done, they are ready for *tanning*. A method stated to be superior to this for bringing them to this state, is one by which the hair may be removed and the hide *raised* in two days. This is done by plunging the hides in old tar water, to which is added five parts of sulphuric to 1,000 of water, and allowing them to remain in it for two days, at which time the hair may readily be removed, and the hide will be found raised. But it is actually stated, that although the practice of *raising* hides be so common, it is in reality of no service to them.

The hides being deprived of their hair and swelled or not, as it may please the operator, he should thus proceed. Instead of laying the hides in a pit with water and powdered bark, he should prepare a strong solution of tannin in water. This can be done by having a number of tubs filled with the powdered bark: on these a quantity of water, (the better if warmed) is to be poured, and as it is drawn off from the first, it is to be added to the second, then to the third, &c. Water should constantly be poured on the first, until it comes off clear, so that nothing may be lost. The solution is to be kept in casks for use, and it is particularly in the use of this solution that the present superiority of tanning leather consists. So soon as the hides are taken from the water and sulphuric acid, they are to be placed in a weak solution of tannin for two or three hours; they are then to be taken out, and introduced in the strongest solution of tan, in such a manner, that their sides may be kept apart about an inch; this can be done by suspending them by one edge. The time in which the hides should remain in this solution, depends on their thickness: from five to twenty days, however, completes the process, which may be determined on, by cutting the hide, as when properly tanned no *white streak* will appear in its middle. When taken out of this solution they should be dried with the usual precaution, so as to prevent an unequal contraction.

It should be observed that leather is tanned, or that the union between *tannin* and *jelly* is much more speedy in summer than winter: This is in consequence of the heat's favoring the combination. Upon reflecting on this, I was led to make an experiment of the following kind, which although imperfectly done, from many circumstances, may serve clearly to shew, that the tanning of leather may be considerably quickened by means of heat. In a very strong solution of tannin, I introduced a bit of hide, and kept the whole in an oven, the temperature of which was from 130° to 150° for thirty six hours. On examining the leather it appeared to me completely tanned, so that I have not the least doubt but that the process might be surprisingly shortened, by means of artificial heat. Tanners will therefore, I think, find it to their interest to change, very materially, their manner of operating, as well as their places for the process. A small room, lined with a mortar of clay and charcoal, appears the best place, to have the hides introduced in the solution of tannin. Through this room, and around the vessels containing the hides, small tin pipes should be arranged, so as to be connected with a small kettle that may be kept constantly boiling over a little fire. The steam passing through would keep up a regular temperature, and in all probability complete the process of tanning in 20 or 40 hours. I sincerely wish this may be attended to by those whose circumstances will allow of making decisive and fair experiments.

In order to avoid the trouble of bringing bark to cities where leather is manufactured, it has been proposed to prepare the decoction or solution of tannin in the forests, and convey it to the manufactories in casks. This would certainly be an improvement. Professor Woodhouse of Philadelphia, who unlike most men, early commenced his career of usefulness, ascertained that very great quantities of tannin were contained in the unripe juice of the persimmon tree, so that at some future day he supposes it will be an object to cultivate the persimmon tree, to yield tannin for the manufactories. The plant vulgarly called *shoemake*, but more properly named *sumach*, has been found to contain immense quantities of tannin. It grows very rapidly, and it might be of great service to cultivate it as well as the persimmon tree, for the purpose of preparing decoctions or solutions of tannin.

IV. OILS.

OILS exist in considerable quantities in a variety of plants, particularly in the seeds. The qualities of oils are so well known, that it is useless to dwell on them. Those obtained from vegetables are divided into two kinds, the one called *expressed* or fixed oils, the other *essential*, volatile or distilled oils.

EXPRESSED OILS.

—

THESE are generally obtained by strong pressure on the seeds of plants. They are thick, mild and inodorous when pure; but more commonly they are blended with the mucilage of the particular plant, which gives them odour, color and taste. The name of the oil depends on that of the plant from which it is obtained, and there are a great variety. I shall only notice three, which are in common use, called *olive*, *castor* and *linseed oils*.

OLIVE OIL.

—

THIS is obtained from the fruit of the olive tree, by mashing it under a kind of millstone. The paste formed by this is conveyed under a plate, on which a large screw is turned so as to produce a very great pressure. The first oil is called *virgin oil*. The paste is then moistened with hot water and again pressed, when an oil less pure is obtained, as it is mixed with a mucilaginous matter, which has a strong tendency to putrefy, and render the oil rancid. Most of this oil of olives of commerce is obtained from Turkey: it is used in making soap, and to season food very generally. Fifteen parts of it are composed of 12 parts carbon and 3 hidrogen.

LINSEED OIL.

—

THIS oil is extracted from the seed of the plant linum, commonly called *flaxseed*. As the seed contains much mucilage, it is roasted, or heated, before it is put under the press. This serves to give the oil a disagreeable flavor, but at the same time, it deprives it of the property of becoming rancid, and renders it one of the most drying oils. Hence it is employed to form paints.

CASTOR OIL.

—

THIS is prepared as the above oil, from the seed of the plant called *ricinus communis*, which should be kept warm while under pressure. It is prepared in considerable quantities by some of the American farmers ; and no doubt but they will find it to their interest to cultivate the plant yielding it much more generally. In doses of about an ounce it is an excellent purgative. Oil of almonds, and indeed all the expressed oils may be had by the above means ; it only being necessary to subject them to a proper mechanical force.

These oils combine with oxigen rapidly, so as to produce inflammation if heated ; or slowly at a low temperature, so as to produce *rancidity*. If exposed to the open air, they slowly absorb oxigen ; this oxigen, when it unites to the mucilaginous part of the oil, renders it *rancid*, and if the oil be confined in a bottle of oxigen air, the rancidity is much more readily produced. From this it must appear that the tendency of oils to become rancid, may be prevented, by depriving them of their mucilage; and this is actually done with great advantage in the preservation of olive oil. The mucilage is soluble in water, and if the oils containing it be well washed in warm water, they part with their mucilage, and the oil can afterwards be poured from the surface and preserved for years, without danger of *rancidity.*

The oil itself also unites to oxigen, and becomes either hard, or of a very drying nature. On this is grounded the art of *painting* with oils. The substances used to give a color to bodies, depends on the whim of the operator. This substance is to be reduced to a very fine powder, and is then to be well rubbed up with the oil; commonly linseed oil is used. The oil with the powder in it is to be thinly and regularly brushed over the body to be painted. The oil then in part evaporates, and in part abstracts oxigen from the air, and thereby becomes solid, so as to form a coat or covering, which retains the coloring matter. To hasten the evaporation, the *paint* is frequently mixed with some volatile substance, as spirit of wine and turpentine. To hasten the union with oxigen, it is common for good painters to boil their oils over the metallic oxids, particularly those of lead and copper. In this case, the oxids part with their oxigen, which unites to the oil, and they abstract a portion of the mucilage from the oil, by which the value of the paint is increased.

ESSENTIAL OILS.

OF the essential oils there is a great variety. They are named according to the plant yielding them. They are characterized by a strong smell; are soluble in ardent spirit, and possess an acid and penetrating taste. It is with difficulty that they can be combined with the alkalies, to form soap.

The essential oil is sometimes distributed through the whole plant; sometimes in the bark, as in cinnamon. Balm, mint, and sage, contain it in the leaves and stems. All the resinous trees contain it in their young branches; rosemary and thyme contain it in their leaves and buds; lavender, the rose, camomile, lemon and orange trees in their flowers; many fruits contain it in their whole substance, as pepper, juniper, &c. oranges and lemons contain it in their peelings, and anise and fennel contain it in their seed. It is to this oil that the plants generally owe their odour.

In order to extract the oils, when they are contained in a disengaged state in the receptacles of plants, they are submitted to pressure. In this manner the oil or essences of lemons, oranges, burgamot, &c. are obtained; but generally essential oils are procured by the distillation of the substances contained in it. For this purpose, the plants containing the oil, are put in a common still, of a small size, and sufficient water is added to cover them. Fire is applied and the oil rises, and is condensed in the condensing worm of the still, from whence it runs, and is received and retained in stopped vessels for use. When much water comes over, and it retains some of the oil of the plant, it is called the *distilled water* of the plant; and when instead of water, ardent spirit is used, then it is termed *spirit of the plant.*

The distilled oils are not so much employed in medicine now as formerly. Many of them are used chiefly as perfumes. That obtained from the distillation of turpentine, and commonly called spirit of turpentine, is prepared in large quantities for the arts. It is frequently used to adulterate the more valuable oils. The fraud may be detected by allowing a drop to evaporate from the hand; when the oils are adulterated with fixed oils, it may be known by putting a drop on white paper, which in that case gives it a greasy appearance.

Essential oils are decomposed in a strong heat. If burnt, more water is formed during the process than when fixed oils are burnt. Hence they must contain more hidrogen, to which they owe their volatility. When allowed to be in contact with oxigen in a low heat, many of them absorb it, and are converted into solids of a resinous nature.

V. GLUTEN.

THIS substance may be obtained by working or kneading a quantity of dough, made of wheat flower, in water. The substance which remains in the hand is gluten. It has been called a vegeto-animal substance, in consequence of its strong tendency to putrefy, during which time it emits ammonia, which shows that it contains nitrogen. It is elastic, ductile, and seemingly fibrous in its texture. It is insoluble in water, and is insipid; dried gently it is rendered hard and nearly transparent, and cracks with a noise. It is, while soft, frequently used as a glue to cement pieces of wood together which are not exposed to a moist air. It exists in a variety of vegetables, particularly in their seed; it is very nutritious to animals, and is composed of hidrogen, carbon, oxigen and nitrogen.

VI. FECULA.

FECULA constitutes the chief part of all the nourishing grains and roots. Barley consists almost entirely of it, and great quantities are contained in wheat, rye, oats, sago, salep, potatoes, and innumerable other vegetable substances. It is to this article that they owe much of their nourishing qualities. Fecula may be extracted from the substances containing it, in a state of purity, by reducing them to powder, and agitating them in water. The water, while turbid, is to be poured off, and the fecula being suspended in it, gradually falls to the bottom. From this it may be taken, washed and dried. It appears in the form of a light, white, insipid, inodorous powder, insoluble in cold, and soluble in hot water, with which it forms a paste.

When fecula is obtained in a state of purity, it constitutes the article commonly sold by the term *starch*, which is used in making pastes, hair powder, &c. Starch may be extracted from wheat, rye, potatoes, or any substance containing it, by allowing them to continue for sometime in the water, until they part with it. It is also obtained from the husks of corn and wheat. The water suspends the finer parts of it, and is to be poured off in that state. On standing for sometime, the starch is deposited, but generally is of a yellow color. To be freed of this, it is to remain in the water, until the water turns sour; then it is to be taken out, and dried and exposed to the sun.

The substances containing large quantities of fecula and gluten are used to make bread. It is on the two, that the art of making it depends; and it is to the two that bread owes its nourishing qualities. The art of making fermented or loaf bread, is of great importance, and is of very ancient date. The substance best adapted for making it, is wheat flour. Of this, three parts should be mixed with two of water, so as to form a paste, which must be well kneaded with a small quantity of yest. This is then to be allowed to rest in a place, the temperature of which being from 70° to 80°. In two or three hours the dough begins to change: carbonic acid is formed, which not passing through the paste, causes it to *rise*, or swell in all directions. This is called *the panary fermentation*. After four or six hours, the dough is then to be made in loaves, and baked in ovens, the heat of which the bakers judge of, by letting fall a little flour, which when the heat is not too high, turns black, without burning. The heat of the oven dilates the carbonic acid, which causes the loaves to rise still more until the crust is formed, which prevents any further alteration in size: then the particles of dough, having exercised the affinities peculiar to them in a high heat, or having *baked*, the bread is withdrawn from the oven. Generally during the baking, the bread loses one fifth of its weight, from the evaporation of water; and this evaporation will continue sometime afterwards, unless the bread be included in wet cloths. After baking, the proximate principles of vegetables, gluten and fecula, cannot be distinguished in the bread.

The excellence of wheat bread over all others, appears to depend on the happy combination of the fecula and gluten in wheat. However, very good bread may be made, by exercising a little art, from other vegetable substances. Rye flour makes a tolerable good bread alone. It may be much improved by combining with it a little barley flour, as this last contains more fecula than the rye, and less gluten, of which the rye has too much. Potatoes also make a very good bread, provided they are freed of a little mucilage, of which they contain too much. For this purpose, the potatoes are to be rasped, or reduced to small pieces, and then washed in water. The water dissolves the mucilage, and is to be poured off, and the potatoe flour dried. Potatoes previously boiled and mashed with a rolling pin, are then to be mixed with an equal quantity of this potatoe powder and baked. The bread formed will be found very agreeable. Perhaps it would be as well to add barley flour to the potatoe dough as the potatoe powder.

VII. INDIGO.

THE valuable stuff dye, called *indigo*, bears a faint resemblance to starch, and has therefore been sometimes classed with it; but its properties are sufficiently remarkable to distinguish it from all other substances, and its importance entitles it to a distinguished place among vegetable principles. It is commonly procured by the following process:

The plant which yields it, is the *indigo-ferra tinctoria*, a shrub which is cultivated for that purpose, in Mexico and the West India islands. When the plant has reached maturity, which requires about six months, it is cut down and placed in wooden vessels of a large size, and covered with water. In this situation, when the temperature is about 80°, a kind of putrefaction or fermentation commences, and goes on rapidly. The water soon has a green appearance; a smell resembling the volatile alkali is exhaled, and bubbles of carbonic acid are emitted. When the fermentation has continued sufficiently long, which is judged of by the paleness of the leaves, and which requires from six to twenty-four hours, the liquid is poured off into large flat vessels, where it is constantly agitated till blue flakes begin to make their appearance; a little lime water is now poured in, which causes the blue flakes to fall to the bottom. The yellow liquid is decanted off, and the blue sediment poured into linen bags. When the water has drained from it sufficiently, it is formed into small lumps, and dried in the shade, in which state it is exported and sold under the name of *indigo*.

Unless the fermentation take place, the plant does not yield indigo; and it is stated that the contact of air is necessary also. The separation of carbonic acid shows that chemical changes are wrought; and the use of the lime water seems to unite to the acid, which prevents the precipitation of the indigo.

Indigo is yielded by several plants. Dr. Roxburg first drew the attention of manufacturers to the *merium-tinctorium*, a tree very common in Indostan, from the leaves of which indigo may be extracted in abundance by a short process. The leaves are kept in a copper full of water, supported at the temperature of 160°, till they assume a yellowish hue, and the liquid acquires a deep green color. The liquid is then drawn off, agitated in the usual manner, and the indigo is precipitated as above, with lime water.

Indigo may be obtained from a plant, growing wild in many places, called *woad*. When arrived at maturity, it is cut down, washed and hastily dried in the sun, ground in a mill, placed in heaps, and allowed to ferment for a fortnight. It is then well mixed, and made into balls, which are exposed to the wind and sun until they putrefy and emit the volatile alkali. The woad then falls to a powder, and is sold as a dye stuff.

Indigo is a fine light friable substance, of a deep blue color. The lightest is the best; but it is always mixed with foreign substances, and the purest of commerce seldom contains more than 50 per cent. pure indigo. It has neither taste or smell. It is neither changed by water or air. When heated it emits a blueish red smoke, and burns away with a faint white flame. The alkaline solutions act upon indigo when it is precipitated from a state of solution, and render it of a green color.

The action of the *acids* upon indigo has been examined with most attention, and they certainly produce most remarkable effects. Concentrated sulphuric acid dissolves it readily. Eight parts of sulphuric acid, when mixed with one of indigo, dissolves the indigo in twenty-four hours. The solution of indigo is well known by the name of *liquid blue*. While concentrated it is black, but when diluted with water it assumes a fine deep blue color, and a drop of it will color several quarts of water.

From experiments which have been made, it is ascertained that all those substances which have a very strong attraction for oxigen, give a green color to indigo, and at last destroy it. Hence it is extremely probable, that indigo owes its blue color to oxigen, and that it becomes green by parting with its oxigen. It is only when green, that indigo is in a state capable of being held in solution by lime, alkalies, &c. in which state it is applied as a dye to cloth. The cloth, when dipped in the solution of it, combines with it, and the blue color is acquired by exposure to the atmosphere; or dipping it in oxi-muriatic acid, by which it unites to oxigen, and soon acquires a blue color. Sulphureous acid, the vegetable acids, and sulphate of iron, (copperas) give the *liquid blue* a green color, by abstracting oxigen.

By the decomposition of indigo by means of heat, it appears to be composed of oxigen, carbon, hidrogen and nitrogen.

DISCOURSE XI.

VIII. SUGAR;

OR

SACHARINE MATTER.

SUGAR, which at present forms so important an article of our food, seems to have been known at a very early period to the inhabitants of India and China: but it was only during the crusades that it was brought from the east, and distributed in considerable quantities in the northern parts of Europe. At first it was used only as a medicine.

Sugar, or sacharine matter, exists in a great number of vegetables. It is afforded in largest quantities by the *sugar cane*, and by the maple and birch trees. The roots of several plants, particularly the *beet* and parsnip, contain it in lesser quantities, as well as the fruit of many plants, as grapes, persimmons, cherries, sweet apples, and indeed all the variety of vegetable substances which excite the sense of *sweetness* in the mouth.

The sugar of commerce is usually procured from the juices of the sugar cane, for which purpose it is cultivated in the East and West Indies. The method of making it is exceedingly simple, and does not require an expensive apparatus. About the end of May, they plant the cane under favorable circumstances, attend to its growth, and in January or February following they are cut down, at which time they are about ten feet high, and one inch in diameter, and have not flowered. The canes are now passed through the rollers of a mill, which press the juice out in vessels prepared for its reception. Three quarts of this juice generally contain one pound of sugar. To extract the sugar the juice is then conveyed to pots properly adapted for the purpose, and boiled in lime water till its consistence is increased. During its boiling, such impurities as arise on the surface are skimmed off. A quantity of blood, towards the last of the process, is added by some manufacturers to free it from some of its impurities. The blood acts entirely mechanically; it is diffused through the mass, and when heat is applied it coagulates, and carries with it many impurities. The lime acts by neutralizing the oxalic and other acids. The sugar, after repeated solution in water, and evaporation, is poured into moulds, where it crystallizes, and in that state is sold in commerce. Its purity depends on the care taken in these processes; and as this varies, we have the sugar either black, brown, refined and white. Such parts as are found not disposed to crystallize readily, are sold under the name of *molasses*.

In the West India islands the raising of sugar is much more expensive, which arises from the nature of the soil, and from the price of labor. It is obtained from the cultivation of the cane altogether there also. But in this country, the farmers procure sugar in several parts for their own use, from the sap of the sugar maple tree, which abounds in the woods. It reaches maturity in about twenty years, and is then from two to three feet in diameter. In February, March and April, the tree is bored with an augur on the south side, to the depth of about three fourths of an inch, in an ascending direction, and then it is made two inches deep. A wooden spout is introduced in the hole, through which the juice flows for five or six weeks. When it ceases to flow from the south, an orifice is opened on the north side, when more sap is obtained. This process improves the trees. Each of them generally yields from twenty to thirty gallons of sap, from which are made from five to six pounds of sugar. The sap should not be kept longer than twenty-five hours after it runs from the tree. It is usually put in kettles; to each fifteen gallons of which a spoon full of lime, the white of an egg, and some new milk is added, when the evaporation is carried on as above, and also the subsequent purification.

In Europe considerable quantities of sugar have been obtained from the *beet*: and for this purpose it is cultivated in some parts. The method of extracting sugar from it, is to free the beet of its heart, and then boil it and press out the juice, or press out the juice without boiling it, as some advise. This juice is then to be strained in woolen cloths, and evaporated as the other juices which yield sugar. It is stated that some beets have yielded one sixteenth of their weight of sugar. This sugar is not at present much used, as it is found to contain something which gives it a disagreeable, nauseous taste: when freed of this, it will be as voluble as any, and no doubt but that in time the beet will be cultivated for the purpose, at least in countries whose commerce is destroyed by war.

The properties of sugar are well known. It is very soluble in water, particularly when the water is hot. In this state it unites to any quantity, and forms *syrup*. To ardent spirit it also unites, but not in such considerable quantities; when heated, it does not combine with more than one fourth its weight. It is one of the most nutritious substances known. In a high heat, without the contact of air, it melts, and if allowed to crystallize, it forms *candy*. A variety of vegetable substances, when boiled in the syrup, are enabled to resist putrefaction; and on this is founded the art of making *conserves*. When sugar is exposed to a high heat it burns, and carbonic acid and water are formed. According to Lavoisier, it is composed of 8 parts hidrogen, 28 carbon and 64 oxigen.

Honey is also a species of sugar, blended with a mucilage, to which it owes its peculiar taste. It is extracted by bees, from a variety of flowers in which it lies exposed to the air. It generally retains the peculiar flavor of the plant from which it is taken. The purest kinds are obtained from northern countries. In its nature, it seems more nearly allied to molasses than to common sugar; and like molasses, is used in some families, not only as an article of diet, but to *preserve* vegetables, as apples, peaches and quinces.

It seems that sugar is frequently formed in animal parts, as in the kidnies of men, during the disease called diabetes; and also during the action of heat on some vegetables. Some apples frequently become sweet while baking; and fecula, during its conversion to malt, also acquires a sweet taste from the formation of sugar. No doubt but that sugar will always be formed, when its constituents are present in due proportion, and those circumstances are created, which are necessary for their action on each other. What these necessary circumstances are, cannot now be determined, and perhaps never will.

Sugar is remarkable for a change which under certain circumstances it undergoes, termed, the *vinous fermentation*, by which a liquor is produced of an intoxicating quality, called, commonly, *ardent spirit*, when distilled; and by the *chemists*, *alcohol*. For this fermentation of sacharine matter, or spontaneous motion, as some call it, there must be a certain degree of fluidity and heat. The products are found to vary, in some measure, with the qualities of the articles employed. On this is founded the difference between wines, beer, cyder, perry, and indeed all the other products of fermentation, which possess an intoxicating property, which they owe to the same substance; namely, ardent spirit or alcohol.

If a quantity of sugar be added to ten times its weight of water, or if any sweet vegetable juice be taken in its stead, and placed in a situation the temperature of which continues from 65° to 85°; it first assumes a turbid appearance; bubbles of air arise and escape with a hissing noise; a froth appears on the surface; heat is given out; the sweetness is gradually lost, and in three or four days a particular pungent taste is acquired; the fluid deposits a sediment and becomes again clear and transparent; it has now acquired a brisk lively appearance, and a vinous odour. When drank, it exhilirates the spirits; when poured out of the vessels containing it, a froth appears, arising from the escape of carbonic acid air; when distilled, it yields the substance called ardent spirit in common language; and when exposed to the air, it is capable of being converted into *vinegar*, or the acetic acid, as before observed.

During this process, the sugar is constantly diminishing, and is finally completely decomposed: one part of it separates in the form of carbonic acid; and the remaining part, a little carbon and much hidrogen, chemically combine together and form alcohol; the intoxicating, or spirituous liquor. The process seems somewhat analogous to combustion, as is evident from the evolution of heat, and formation of carbonic acid.

WINE.

THIS product of fermentation, is obtained under circumstances like the above, from the expressed juice of the grape. The grapes are put into a vessel, when the temperature is about 50° after they are bruised and much agitated. Then fermentation is excited, and the before mentioned appearances take place. When the fermentation ceases, the wine is drawn off from the lees into casks, where it undergoes a second, though insensible fermentation, which more intimately developes its principles, and it is this change which causes the difference between the *old* and the *new* wines of the same kind.

The properties of wine differ very much from each other, these depending on the nature of the particular grape, and the manner in which the process is conducted. These differences are known by all who drink wines. All the various wines contain more or less of the following ingredients, not to mention water, which constitutes a very great proportion of every wine.

1. *An acid.* All wines give a red color to paper stained blue, and of course contain an acid. The malic, citric and tartareous acids are very generally met with in them. Such as have the property of frothing, owe it to carbonic acid.

These wines are usually weak, their fermentation proceeds slowly, and they are put up in close bottles before it is over. Hence they retain the last portion of carbonic acid which were evolved.

2. *Alcohol.* All wines contain more or less of this intoxicating spirit, and in proportion to the quantity is the strength of the wine. From one fourth to one fourteenth of the wines is usually alcohol; and it can only be separated by distillation. It is then called brandy. The quantity depends on the quantity of sugar in the grape juice.

3. *Extractive matter.* This exists in all new wines; and it is to this that they owe their power of undergoing the acetous fermentation. The quantity of it diminishes with the age of the wine, as it is gradually precipitated from the wine while at rest.

4. *Oil.* Every wine is distinguished by a peculiar flavor and odour, which probably depends upon the presence of a *volatile* oil, so small in quantity that it cannot be detected.

5. *The coloring matter*, is derived from the husk of the grape, and is not dissolved till the alcohol is developed. This matter is analagous to the other coloring matter of plants. It may be precipitated if the wine be exposed to the heat of the sun. It is sometimes lost by age, and it may readily be destroyed by a little lime water. Perhaps the husk of grapes would answer well for coloring all spirituous drinks.

Before dismissing the subject of wines it may be remarked, that the sweet taste of the sweet wines arises from a quantity of sugar they contain, which was not fermented.

In some instances a little sugar is added. In others the adulteration is greater, and the entire qualities of the wine are altered, or imitated by innumerable arts. The red wines are frequently adulterated with sugar of lead and alum. The first article may be detected by adding a little sulphuric acid, which unites to the lead, forming an insoluble compound. By adding the sugar of lead to the wine containing alum, the same compound will be formed.

By processes similar to the above, the juices of gooseberries, apples, pears, persimmons, cherries, &c. may be made into drinks equally pleasant, in the opinion of good judges. They are generally improved by evaporating part of their water, by boiling before fermentation. The same advantage will be derived by adding a little sugar to them, and it is much to be wished that more attention was paid to the preparation of these drinks, as it would supersede the use of imported articles of the kind.

PORTER;

OR

BEER.

PORTER is made of the first quality in London, by Mr. Biley, in the following manner: Barley is first reduced to malt by being steeped in warm water for five or six days; it is then drawn off, and the barley is spread upon the floor, about six inches thick, when it begins to germinate, which is allowed to continue until the *sprout* is two thirds or three fourths of the length of the grain. When this is accomplished, the grain is spread thinner, and turned over twice a day for several days; it is then transferred to the kiln, heated with wood, and dried till it acquires a brown color; it is then called *brown malt*. From this malt porter is brewed in the following manner:

A quantity of malt, freed from its germ, is coarsely ground and put into a vessel called the mash tub. Water heated from 160° to 180°, is poured on it, and the whole is stirred intimately together, either by machinery or the hand, so that the soluble part may be extracted. When this operation is over, the liquor called the *extract*, is drawn off. Another infusion is then made by means of water of a higher temperature, which of course is weaker than the former, and these are either mixt or kept separate. Both have a sweet taste; they contain the sacharine, the extractive, and the glutinous parts of the grain. The infusion thus obtained is called *wort*. It is then boiled with hops, to give it a certain aromatic bitterness, and to render it less liable to spoil in keeping. It is then cooled as expeditiously as possible in very large shallow vessels, called *coolers*, in which it measures only one or two inches deep. As soon as it is cooled it is put in the *fermenting tub*, with a little *yest*, (which is nothing more than the same article fermenting) and the whole is suffered to ferment. When the fermentation has advanced to a due degree, and the yest ceases to rise, the beer is divided into smaller casks to facilitate the separation of the yest; and lastly, it is conveyed into barrels, and kept in cool places, with the precaution of supplying the loss it suffers by evaporation. Eight bushels of malt and ten pounds of hops produce, upon an average, one hundred gallons of London porter.

The grains of rye, oats, corn, and many other vegetable matters, which either contain sugar, or the ingredients which may be converted into sugar, are frequently employed for making beer. Their strength is increased, by adding molasses or sugar. They should all be kept in tight vessels, after properly fermented, to prevent their becoming *dead*, to use a common phrase, or to keep them from parting with their carbonic acid or fixed air and spirit.

When honey is blended with water, and allowed to ferment as above, it retains a peculiar flavor, and the drink is called *mead*.

But whatever be the peculiar nature of these various fermented drinks, they all contain what is called *ardent spirit;* and it is to this that they owe their intoxicating quality. They all yield it when subjected to distillation in the usual way. This spirit is formed by a change in the chemical combination of the constituents of sugar. This chemical change arises from a certain state, created by water and heat, in which those affinities of the substances peculiar to that state are exercised, in proportion to the quantity of the substances present. The *yest* quickens or promotes this change, as the same fermentation is going on in it, by which the *particular state* for the chemical change is communicated to the rest of the mass.

ARDENT SPIRIT, ALCOHOL;

OR

SPIRIT OF WINE.

AS before observed, when the fluids which have undergone the vinous fermentation are distilled, there comes over a substance called commonly *ardent spirit:* by the chemists the term *alcohol* is applied to it when in a state of purity. To obtain it pure, it is necessary to subject it to repeated distillation; when this is done, it is found colorless, possessed of a penetrating odour, and an intoxicating quality when drank in but small quantities. It is capable of being inflamed without a wick, and burns without smoke. The products obtained by its combustion are water and carbonic acid, which shews that like essential oils, it is composed, of carbon and hidrogen. It is very volatile and consequently evaporates spontaneously at common temperatures. It boils at 176°. It combines with water, sugar, resins, the alkalies, essential oils, camphor, &c. It resists the putrefaction of several vegetable and animal substances, when they are immersed in it.

The ardent spirits in common use, are very far from being pure. They all retain the particular qualities of the vegetable substance from which they are procured, as well as a considerable quantity of water, from which, they can only be freed by frequent and cautious distillation.--- The flavor, it is well known, of the grape, apple, peach and persimmon, exists in the *brandy*, which is formed from each of them; of the rye, in *whiskey;* of the juniperberry, in *gin;* of the cane, (or molasses) in *rum*, &c. The strength depends on the quantity of alcohol in them. The parts which first come over during distillation, are always purest or strongest. In order to judge of the degree of purity or strength of the spirit, several methods have been proposed. They are all however fallaciou , excepting that, by which the *specific gravity* is ascertained. When the liquor is perfectly pure, as in spirit of wine repeatedly distilled, the specific gravity is 0.800; but it is seldom found so pure. The specific gravity of the alcohol of commerce, is seldom less than 0.8371; it is scarcely necessary to remark, that the increase of specific gravity is always proportionate to the impurity of the spirit. When it is not convenient to weigh the spirit with proper caution to ascertain its specific gravity, an idea may be judged of it by using a phial, which when empty, sinks into pure water to a certain height. On filling it with the spirit, and introducing it in water, the degree to which it sinks, will indicate the specific gravity of the spirit. In measuring spirit, it should always be recollected that it is much expanded by heat.

There have been many attempts made to purify or increase the agreeable qualities of the spirituous liquors in common use, by making additions to the usual mode of procuring them. It seems in some instances to be an improvement to the spirit, to let it pass through pounded charcoal, or to distil it with this substance. In some instances, the spirit is mixed with an alkali, then on distilling it, a little nitric or sulphuric acid is added, by which means a little ether is formed, which is supposed to increase the good qualities of the liquor. These liquors may be colored, by burnt sugar, the husks of grapes, or any coloring matter not injurious to life.

ETHER.

ALCOHOL unites to the oxigen of acids under certain circumstances, and forms the very odorous, volatile, pungent and inflammable fluid, called *ether*. The qualities of this ether are somewhat influenced by the particular acid which is added to the alcohol. This has given rise to the differences in the names of the ether, which are called according to the acid employed, as the sulphuric, nitric, acetic, muriatic and phosphoric ether.

SULPHURIC ETHER.

TO prepare this ether, any quantity of sulphuric acid is gradually mingled with an equal weight of alcohol in a retort, connected by a tube to a receiver, which is kept cool. Heat is applied to the retort, and a colorless fluid rises and condenses in the receiver. When the distilled fluid amounts to about half the quantity of spirit employed, or when the neck of the retort becomes obscured with white fumes, the distillation is to be stopped. A thick black liquid remains in the retort. The distilled liquor, which is the ether, impure from the admixture of water and sulphureous acid, is to be mixed with a little potash, and again subjected to distillation by a gentle heat, when it comes over in a state of purity.

NITRIC ETHER.

THIS may be prepared in the following manner: Two parts of alcohol are poured in a strong glass bottle provided with a ground stopper, and placed in a cold mixture, where the temperature is below the freezing point. One part and a half of nitric acid, also made cold, is to be cautiously added drop by drop, and at intervals sufficiently long. When the mixture is completed, the glass is for some time left in the cold, and well stopped. After this, the ether is found swimming on the surface, from which it is to be carefully taken off; and to have it more pure, it may be cautiously distilled upon a little potash.

ACETIC AND PHOSPHORIC ETHER

MAY be obtained by distilling equal parts of the strongest acids of these kinds with alcohol, and proceeding as in the first instance. No good method of obtaining *muriatic ether* is known, as the methods recommended do not furnish a fluid possessed of all the properties of ether.

It is only the sulphuric and nitric ethers which are frequently made. They are chiefly used as a medicine in repeated doses of two or three tea spoons full in low fevers, particularly of the nervous kind. They are also employed to dissolve a few substances in the arts.

IX. GUM.

HAVING now considered sugar and the modifications to which it is subject, we proceed to the consideration of the next vegetable principle, which is gum, or mucilage. This is found in all young plants, and often exudes spontaneously from certain trees, as the cherry, peach and plumb trees. The *gum arabic* of the shops is obtained from the tree called the *mimosa nilotica*; large quantities of gum exist in the seeds of some plants, as quince, water mellon, and flax seed, from which it may be extracted by hot water; as also from the bark of the *elm*, from marshmallows, &c. Gum, when dried, is void of odour and taste; is not fusible or volatile, is very soluble in water, but not in alcohol. With water it forms an adhesive paste. It is very nutritious to animals, and is consequently used as an article of diet in some places. More generally it is employed in the arts. When subjected to a high heat, it yields products showing it to be composed of oxigen, hidrogen, carbon, nitrogen and lime.

X. RESIN.

THIS is a substance also met with in considerable quantities in vegetables, particularly in the wood, bark and roots of trees. It may be extracted from them, by infusing them in ardent spirit, which is afterwards to be evaporated; but a number of trees suffer it to exude through them as gum, from whence it is collected in a tolerable state of purity.

The properties of pure resins are as follows: They possess a small degree of transparency, and a color generally inclining to yellow. When exposed to heat, they melt, and if in contact with oxigen air they burn, emitting at the same time much smoke. They are insoluble in water, but are very soluble in alcohol and oils, particularly in the oil of turpentine; and when in solution, they are used for *varnishes*.

The resins obtained from plants are almost universally mixed with other substances to which they owe their taste and odour; though when pure, as in *copal* and *sandarach*, they are nearly insipid and inodorous. Their effects on animals are considerable, and many of the vegetable remedies owe their activity to the resin they contain, as *aloes*, *scammony*, &c. However, as those substances which contain most resinous matter possess nearly the same properties, it would be useless to dwell on each of them. The most distinguished of the resins, are *rosin*, *copal*, *sandarach*, *mastich*, *elemi*, *dragons blood*, and the several *turpentines* and *balsams*.

Rosin is obtained from different speties of *fir*, as the pinus abies, sylvestris, larix and balsamea. It is well known, that a resinous juice exudes from the pinus sylvestris, or common scotch fir, which hardens into tears. These tears constitute the substance called *thus*, or common frankincense. When a portion of bark is stript from these trees, a liquid juice flows out, which gradually hardens.--- The juice has obtained different names according to the plant from which it comes. The pinus sylvestris yields common turpentine; the larix, Venice turpentine; the balsamea, balsam of canady, &c. All these juices, which are commonly distinguished by the name of *turpentine*, are composed of two ingredients; namely, oil of turpentine and rosin. The oil is separated by distillation in common stills; great care being taken not to have the heat too strong, and to keep the condensing tube very cool. When the oil is distilled, the rosin remains behind. When the distillation is continued to dryness, the residuum is known by the name of common rosin; but when water is mixed with it, while yet fluid, and well agitated, the mass is called *yellow rosin*. The yellow rosin made by melting and agitating this substance in water, is preferred for most purposes because it is more ductile, owing probably to its containing a little oil.

Common tar may be considered as somewhat allied to turpentine. It is obtained by burning the pine trees, particularly the roots, in a place covered in great measure with earth; so that the combustion is very slow, and in consequence of this, the resin melts, acquires a black color from the combustion, and runs out at orifices, made in depressed parts for the purpose. From this it is taken and put in barrels and sold for the numerous purposes of commerce. The tar when boiled, parts with its *oil*, to which it owes its fluidity, and is then converted into *pitch*. Perhaps it would be of some advantage at ship yards where much pitch is made, to have contrivances for the purpose, by which all the oil might be saved during the conversion of the tar into pitch. Tar is also used in the healing art. When mixed with fat, it forms an excellent ointment for the disease called the *scalled head*. Water digested on it for sometime, (*called tar water*) has been drank by patients laboring under debility with advantage.

OF VARNISHES.

RESINOUS substances form the base of all *varnishes*. A coat of varnish ought to resist the action of the air and water, and not change such colors as are underneath; it should be easily spread over the whole surfaces of bodies, without leaving cavities or pores; and it should not crack or scale off. Resins are the only substances possessed of these properties.

To form a varnish, resins must be most intimately blended, or rather must be dissolved in some fluid, so that they may be properly applied to the surfaces of bodies. They are usually dissolved in expressed and essential oils, and alcohol, forming the kinds of varnish, called the *oily, essential*, and *spirituous* varnish.

Before the *oily* varnish is made, the oil should be boiled over *litharge*, or any of the metallic oxids; by which, they unite to oxigen, and acquire a stronger tendency to evaporate and become hard. The evaporation is usually quickened by the addition of a little oil of turpentine.

The *essential* varnish is usually formed by dissolving the resin in the oil of turpentine.

The *spirituous* varnish is formed by dissolving the resin in ardent spirit. This varnish is subject to *cracking* when applied, to prevent which, a little oil of turpentine is added, which also increases its lustre, The best kinds are made of the resins called copal, sandarach and mastich.

The copal varnish is deemed by far the most valuable: the copal is obtained from a tree growing in the North and South America. It is a beautiful transparent resinous like substance, with a slight tinge of brown. When heated, it melts like other resins; but it differs from them in not being soluble in oils of turpentine and alcohol, without particular management; nor does it unite with the fixed oils as readily as the other resins. When it is kept melted till a sour smelling aromatic odour has ceased to rise from it, and then mixed with an equal quantity of linseed oil which has been deprived of all color, by exposure to the sun, it unites to the oil, and forms a varnish which must be dried in the sun. If it be desired to dissolve the copal in oil of turpentine or alcohol, it is necessary that the heat should be above the boiling point, which can be made so, by heating the articles in a strong covered vessel. Or instead of this, it has been proposed to dissolve the copal in the steam of these solvents, by causing them to boil in closed vessels, while the copal is suspended just over them, where it melts and is dissolved. It forms a colorless varnish, which may be applied without injuring the colors underneath.

To increase the lustre of varnishes after the *solvent* of the resin is evaporated or dried, they are rubbed with pounded pummice stone and water; then they are rubbed dry with an oiled rag. The surface is cleaned of all oil, by rubbing it with soft linen rags, with a little starch powder, and then with the clean palm of the hand.

BALSAMS.

SUCH resins as spontaneously issue from their plants, owe their fluidity to an ethereal oil which is combined with them, as also their fragrant smell. While they retain this oil, some of them are called balsams; and all the balsams of the shops may be considered as resins dissolved in an oil. These most generally met with, are the balsams of Capaiva, of Peru and of Tolu. These like most of the resins are procured by making incisions in trees, and collecting the juices in proper vessels, where they are covered to prevent the evaporation of this oil. These are occasionally used in medicine as a stimulant to the kidnies, in small and repeated doses of from ten to thirty drops.

There is a chemical combination of certain proportion of resin with gum, forming compounds called *gum-resins*. These compounds possess the property of dissolving equally well in ardent spirit and water. The most remarkable of these are the substances of the shops, called gum, galbanum, gum myrrh, opium, gum asafoetida, &c. They exert more action on animals than any pure resins or gums: and when dissolved in spirit constitute the *tinctures* of the shops, as the tincture of aloes, tincture of opium or laudnum, &c.

XI. EXTRACT.

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EXTRACT exists abundantly in the juices of all plants. It is soluble in water, ardent spirit, and in diluted acids. It may be obtained from plants by macerating them in water, and then evaporating it by a moderate fire. When the temperature is at the boiling point, and the extract is in contact with the air, it unites to oxigen, forming an insipid substance no longer soluble in water; in which respect it differs from gum-resins. Many of the medicines owe their virtues to this extractive matter, from which it is obtained by infusing them in water: of this kind are the extracts of Peruvian bark, of opium, of liquorice, &c. They should be covered from the air, while making, to prevent the absorption of oxigen, which destroys their virtues.

12. ELASTIC GUM;

OR

CAOUTCHOUC.

THIS is a part of some plants remarkable for its elasticity when dried. It is principally obtained by puncturing certain trees of South America, called the *caoutchouc*, and the *jatropha elastica*. It exists also in the misletoe, in gum mastich, and in various plants. It is first thick and milky, and becomes hard on exposure to air. It can be stretched to a considerable extent without breaking, and when the force is withdrawn it immediately contracts. The blackish color of the caoutchouc or *Indian rubber* of commerce, is owing to the method of drying it. It is soluble in ether and volatile oils. It is softened but not dissolved by water. It is insoluble in ardent spirit, and it loses its elasticity by heat. It is chiefly employed in the arts for making bottles, catheters, &c. for which purpose it is previouly dissolved in ether, and then applied to the skeletons of the vessels, when the ether evaporates. Its elements are carbon, hidrogen, oxigen, and nitrogen, as will appear by the products it yields when subjected to a strong heat.

13. CAMPHOR.

THIS is a substance which exists in a great variety of plants. It is found in large quantities in the *laurus camphora*, which grows in China, Japan, Sumatra, &c. And it is also obtained from the roots of zedoary, from thyme, rosemary, sage, and from many other of the odorous plants which contain essential oil after they are allowed to *dry*. Most of the essential oils deposit camphor, when they pass to the state of resin, by the absorption of oxigen. But the camphor of the shops is chiefly obtained from the East Indies, where it is extracted by distillation from the roots, and in want of these from the other parts of the laurus camphora. These are put with water in an iron still, without a long *worm* attached to it (in which state it is called an *alembic.)* In the head of the still cords of rice straw are arranged regularly across it, and the head is then placed on the still and fire applied. Part of the camphor sublimes and attaches itself to the straw within the head; while another portion is carried into the receiver with the water. The camphor is then brought to Europe, and has hitherto been purified chiefly in Holland, by subliming it in large glass vessels, with one ounce of lime. Professor Woodhouse has written an excellent paper on the purification of camphor in the Medical Museum, published by the very useful and respectable Dr. J. R. Coxe of Philadelphia.

Camphor when purified, is a white concrete substance of a strong smell and taste; very volatile, soluble in ardent spirit, and resembling in some of its properties the essential oils. It burns readily, leaving nothing behind. The products formed are carbonic acid and water, which shew that it is composed of hidrogen and carbon. When the nitric acid is distilled from it, an acid is formed called the *camphoric acid*, which has a bitter as well as sour taste.

Camphor is one of the best remedies used in the healing art. It is given in doses of 5 or 10 grains 5 or 6 times a-day in nervous fevers with great advantage. Rubbed up with water and sugar, or mucilage, it forms a julep much used in the above cases. Dissolved in ardent spirit, it is applied to parts affected with chronic rheumatism, with great advantage.

XIV. WAX.

THE obvious qualities of wax are well known. It is obtained from the vessels holding the honey of bees. The bees procure it from the flowers, leaves, and other parts of vegetables. When exposed to heat it melts, and if in contact with oxigen it burns very readily. With the alkalies it forms soap. It is insoluble in water or ardent spirit, but is soluble in essential and expressed oils. It bears the same relation to the expressed oils that camphor does to the essential. It appears to owe its solidity to oxigen, and has consequently been considered as an *oxid of expressed oil.* When distilled an oil is obtained from it.

The wax, when obtained from the bee hives, is of a yellow color. In order to *bleach*, or render it white, it is usual to expose it to the open air and sun for some time. A more expeditious method of bleaching it, is to expose it to the action of the oxi-muriatic acid air.

Wax is the basis of most of the plasters used by physicians. It is used also to give a gloss to good house furniture.

XV. BITTER PRINCIPLE.

MANY vegetable substances have a very bitter taste, such as quassia wood, gentian, and columbo roots; leaves of the hop, Peruvian bark, camomile flowers, and coffee. These owe their power of exciting the sense of bitterness, to a particular substance called the *bitter principle*. No chemical examination of this, has hitherto been published, nor are we acquainted with the means of separating it from other bodies, or ascertaining its presence except by the taste. It may, however, be procured tolerably pure, by digesting water over quassia wood split fine, until it becomes of a yellow cast and very brittle; this is then to be evaporated by a slow fire; and a substance will remain in the vessel of a brown color, intensely bitter, and very soluble in ardent spirit and water.

It is the bitter principle of plants, which is supposed to give them the power of strengthening the animal system, or in other words, giving tone to the body. As it is soluble in water and ardent spirit, it is most generally given to increase the tone of the system, either in water, forming an infusion, or in ardent spirit, forming a tincture. They act as a strong artificial stimulus to the system, and their use should be avoided by all who are in good health.

XVI. NARCOTIC PRINCIPLE.

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THIS principle has never been obtained pure. Its existence is only known by its powerful effects on animals, inducing sleep, disease and death, in small doses: hence it is called, also, *soporific* or *stupifying* matter of plants. It exists in largest quantities in fox-glove, opium, leaves of the cherry laurel, of the deadly night shade, of the thorn apple (datura stammonium,) of the common black henbane, of the wild rosemary, of tobacco, in lettuce, &c. It appears soluble partly in water, and partly in ardent spirit.

Besides the fifteen substances just considered, as the proximate principles of plants, others have been named by different authors, as the *acrid principle*, *coloring matter*, *suber*, or common cork, which is found in the barks of trees; *sarcocall* or common liquorice, and one or two others.--- Perhaps some of them, as well as others that one would notice while examining the products of the vegetable kingdom, may possess properties a little different from the substances we have considered. But this should not lead persons to form an endless list of the proximate principles of plants; to avoid which, such bodies should be classed among those they most resemble.

PUTREFACTION OF VEGETABLES.

THE various substances forming vegetables, finally undergo changes by which they are converted into elements, or into compounds of a different kind. This is usually called putrefaction. The tendency to it differs in different plants, and this tendency in the same plants varies with the circumstances in which it is placed. It takes place generally more speedily in the presence of atmospheric air impregnated with moisture and warm seasons; and when the quantity of vegetable matter present is considerable. The bulk of the mass gradually lessens, and becomes soft; carbonic acid, and other disagreeable airs are extricated; heat is generaly made sensible, and the greater part of the mass is carried off. The remainder consists chiefly of carbon, lime, potash, soda, or any other fixed body which may not have been converted into air: this gradually becomes blended with the earth, and serves for the growth of other plants.

The substances formed during the putrefaction of the plants, must at once appear to depend on two causes; one is the particular substance present in the vegetable, and the other is the particular *state* or *circumstances* created for their affinities to be exercised. Hence carbonated hidrogen, carbonic acid, nitrogen, ammoniacal, and many other airs, are occasionally thrown off from vegetable putrefying matter.

Before dismissing this subject, it may be of use to subjoin the following statement, which contains a general view of the most striking properties of the proximate principles constituting vegetable substances.

1. *Wood or ligneous fibre.* Tasteless, insoluble; resists putrefaction; leaves much charcoal when heated in a close vessel.

2. *Acids.* Possessed of all the general properties of acids; easily decomposed by heat. Six different kinds, the citric, malic, oxalic, gallic, benzoic, tartareous and acetic.

3. *Tannin.* Soluble in water and ardent spirit; precipitated by gelatine, or animal jelly. Taste astringent; unites to the jelly of hides, forming *leather*.

4. *Oils.* Two kinds: volatile or essential, obtained chiefly by distillation: *expressed* or fixed, obtained by pressure on seed. Of each kind, several varieties, named according to the name of the plant from which it is obtained. All of them unite to the alkalies, forming *soap*. They are combustible.

5. *Gluten.* Soluble when extracted from the plants. Coagulated by the heat of boiling water. Readily putrefies, emitting ammonia.

6. *Fecula or starch.* Insoluble in spirit or cold water. Forms a paste with hot water. Taste insipid. Exists in many of the nutritive seeds and roots of plants. When in a state of combination, as in wheat, undergoes the *panary fermentation*, by which it may be made into loaf bread.

7. *Indigo.* Obtained by fermentation; color blue. Insoluble in alcohol and water. Soluble in sulphuric acid, forming the *liquid blue*, much used in dyeing.

8. *Sugar.* Taste sweet. Soluble in water and alcohol. Obtained from many plants. Is susceptible of undergoing a change when combined with more than one fourth its weight of water, by which it is converted into vinous liquids, which on distillation yield alcohol or ardent spirit; which unites to the acids, forming *ether*.

9. *Gum.* Soluble in water, in which state it is called, *mucilage*. Insoluble in alcohol. Taste insipid. Very nutritious, and abounds in many plants.

10. *Resin.* Insoluble in water; soluble in alcohol, ether and oils, in which state it forms a *varnish*. With the oils from trees they constitute turpentines and balsams.

11. *Extract.* Soluble in water and alcohol; insoluble in ether; unites to oxigen when heated, by which it loses its power to act on animals.

12. *Elastic gum.* Very elastic; insoluble in water and alcohol; soluble in ether.

13. *Camphor.* Strong odour; may be sublimed by heat; insoluble in water. Soluble in alcohol and oils. May be converted to an acid: burns with a clear flame.

14. *Wax.* Insoluble in water. Soluble in alcohol, ether and oils. Burns very readily, and is very fusible.

15. *Bitter principle.* Soluble in water and alcohol; Very bitter; acts as a tonic on animals when swallowed.

16. *Narcotic principle.* Sparingly soluble in hot water and alcohol. In large quantities is a deadly poison to animals.

All of which substances, either alone or in combination, as they exist in plants, finally undergo a putrefaction or decomposition, by which they are either converted to the elementary state or into other compounds less complicated.

DISCOURSE XII.

WE have seen the different substances, which are contained in plants. We have now to examine the manner in which these substances are produced, and the circumstances favoring their production. We have stated that they were chiefly composed of *carbon*, *hidrogen*, *oxigen*, and *nitrogen*, with but small portions of *heat*, *light*, and occasionally of five or six other elementary bodies. It must readily appear that those elements are not applied for the growth of plants in a pure state. To determine in what states of combination they are afforded for the formation of vegetable bodies, must be an object of considerable importance to the agriculturist.

Natural historians have long since observed, that all plants arise from *seeds*, situated in the soil or earth, under particular circumstances. When situated in the earth, where their elements exist they vegetate; their structure, and their qualities become materially altered; each particular seed assumes the particular form for which it was intended, or rather which seems stamped on it by nature. The roots, extend considerably, they absorb the food for the plant, which is conveyed in vessels to the various parts, where it acquires the necessary properties. In the first state, into which it is changed, it is commonly called *sap*. This *sap* is afterwards changed into innumerable different states, to suit the purposes of the respective parts of each plant.

The food being applied to the roots of plants, we must inquire by what means it unites to the seeds, and then circulates through them in the state of *sap*.

To explain this, philosophers have been at great pains, and have offered a variety of conjectures more calculated to shew their ingenuity than to account for the phenomena. They have, however, at length made satisfactory explanations. Having ascertained that the seeds and roots of plants were porous, and that porous bodies absorbed moisture; and having clearly shewn that vegetable bodies contain vessels, which possess the power of contracting and dilating, or in another word *irritability*. It now appears very obvious and certain that the roots, by virtue of their orifices or pores, attract the fluid substances around them, and convey them to the vessels possessed of a contracting power, at which time these small vessels contract and propel the juices or *circulate* the sap through them. This simple explanation has not been very long made. The whole circulation of the juices was attributed to this *porous*, or, as it is called by philosophers, *capillary attraction*. The discovery that vegetables possess *irritability*, led to the rejection of this supposition. That it is in consequence of this *irritability* of the vessels that the fluids are circulated in them has been rendered unquestionable, by Professor Barton of Philadelphia, who has much raised abroad the character of his country, as the seat of science. This celebrated naturalist found, that plants growing in water vegetated with much greater vigor, provided a little of that powerful stimulus, camphor, was thrown in the water. From some experiments which I have instituted, I am led to believe that a little ardent spirit will produce the same effect.

The next and not less important inquiry, which presents itself for our consideration, is the means by which the food of plants is *assimilated*, or changed into a substance of the same nature as that of the plant; or, in other words, the means by which the matter entering the plants is converted into sap, and this sap into the various compounds found in plants.

To account for these important changes wrought in the vessels of plants, philosophers have advanced but two theories which have a claim for the least attention. The first which prevailed was: that the various substances found in vegetables, previously existed in a *formed* state in the food, that the vessels of the plants served merely to filter, strain, or separate these fluids, and that when the sap passed through any part, it left that particular substance behind which was necessary for the part, and which could not pass through the *strainer* or vessels. This is called the mechanical theory of secretion. It surprises us in nothing more than that it should have ever been seriously believed by any one. For it realy seems difficult to have credulity enough to believe that so many thousands of substances could exist in the sap of plants without one's being able to detect the presence of any of them.

The next theory advanced to explain the mystery was: that in consequence of the irritability of the vessel of plants, these vessels when the sap was conveyed to them contracted and dilated, or in other words so acted as not only to cause the sap to pass through them, but to change its state from that of sap to sugar, gum, resin, wood, &c. And thus it is stated, that by a *peculiar action* of the vessels on the sap of plants, are all the changes wrought which we notice in the vegetable kingdom.

This theory early struck me as being incorrect. How the simple action of tubes could cause not only the circulation of a fluid through them, but its conversion into innumerable states I really could not conceive. It appeared to me, that the true theory, characterized by simplicity, remained to be revealed.

In the course of my pursuits I frequently noticed, that the affinities or laws of the same compound, were changed by change of circumstances. Throughout these discourses I have endeavored to impress the same on others. Indeed, no one can doubt it who has mind enough to form a distinct idea. No one will say, that the particles constituting bread, exercise the same affinities in a heated oven, when they are converted into charcoal, as they do when left at a common temperature. We *must* attribute the difference in all such cases, to a difference in the affinities of the matter exercised; and we must attribute this different exercise of affinities to a difference in the circumstance, state, or condition in which the bodies are placed. This we must do, although we cannot say on what the particular state depends. And although we know not, in what one *state* differeth from another.

In the course of this work I have stated, and it will be believed by all who examine, that not only heat, light, electricity and galvanism, create states in which the affinities of the particles of matter are variously exercised, but that *other bodies* have sometimes great influence in creating states for the exercise of the affinities of matter of a different kind. Hence you may put two compounds together of a particular kind, and no action will ensue unless water be added, which, when done, new affinities are exercised, and the water remains unchanged. A number of similar facts might be mentioned. The observation before made may be here repeated, namely, that although we cannot say in what, a state for the exercise of the affinities of matter consists, yet it no doubt depends on a *mechanism*, or mechanical arrangement of matter which cannot be described. A variation in the mechanism of a body, would naturally lead us to suspect that there would be a variation in those affinities of a compound which were exercised in the first state.

Aware of these considerations, or principles, the changes occurring in vegetable juices can no longer be mysterious. Throughout every part of every plant there are pores, or vessels: and in almost every part, there is a difference in the mechanism or arrangement of these vessels. Inasmuch therefore, as we find a difference in this mechanism, should we be led to expect a difference in the affinities of the matter exercised. Accordingly we find that the compounds existing in the different parts of plants, do vary as much as their mechanism or organization.

The theory then to explain the formation of vegetable substances, seems very simple. A seed is placed in a soil; it attracts substances from the earth; these substances constituting its food enter the pores or vessels of the seed; in these pores, or in this state their affinities are exercised, in consequence of which they are converted into sap; the different parts of the plant have a different mechanism, in consequence of which this sap assumes in one part, properties different from those in another; in one part, its affinities are exercised whereby it is converted into fibrous vessels possessed of irritability or a contractile power; in another it is converted into mucilage; in another into sugar; in another into resin; in another into an acid; and so on of every juice found in plants. And thus a particle of matter may have its affinities exercised, and then itself be an agent creating states in which the same affinities of other matter are exercised.

It should not from this be supposed, that all the parts of a plant are composed of the *same* elements; although they are all formed from the sap, and on the same principles, viz. by the exercise of affinities regulated by a mechanism, or state created by some intervening body. This would be incorrect, as we find on analyzing some parts, their elements differ in proportions very considerably. If we can conceive of the different exercise of the affinities of particles of matter in different states, we can conceive that when the sap passes through certain vessels, most of one or two of its elements may go unchanged, while its other elements are altered: for example, we can conceive of the hidrogen and carbon of the sap uniting in one part to form oil; and the remaining constituents of the sap passing unchanged for other purposes; in another part, the oxigen is retained in a small quantity, so as to form a *sugar* with the hidrogen and carbon; in another part the oxigen is retained in such quantities as to form an acid; and so of all the rest of vegetable substances.

No doubt, light has considerable influence in creating states for the exercise of the affinities of the sap in the upper parts of the plant. In the ripening of fruit, its influence is remarked by every one. This ripening of fruit, by which acid and acrid juices are converted into such as are sweet and mild, tends very much to establish the explanation of vegetation, which I have ventured to offer. The conversion of sour fruit when baked into a sweet mass has the same tendency. In each of these cases, the changes must unquestionably arise from the different exercise of chemical laws in different states. Surely in an apple, a water mellon or a strawberry, there are no little vessels which can make sugar by a *peculiar action*.

Having given the above explanation of vegetable growth and secretion (which from the obscurity of the subject will I fear appear obscure to some) I shall make mention of some of the most remarkable functions of the upper parts of plants, and will then proceed to the consideration of the soils most favoring vegetation.

It is known that after the seeds of plants sprout, that a part rises out of the earth, on which is formed seed for the future propagation of the same plant. On this part we almost universally meet with *leaves*. These leaves are found to act as important a part towards the upper part of the plant, as the roots do to the lower part. Hence the plants soon decay if deprived of the one or of the other. Nor is this surprising, for a number of experiments have very decidedly shewn, that they are instrumental not only in preparing nourishment but in receiving it from the atmosphere for the support of the whole. They are to the plants what the lungs are to animals.

The sap is no sooner conveyed to the leaves by the contraction of the vessels, than a considerable part is *transpired*, or thrown off by evaporation. The quantity thus transpired, bears a very great proportion to the moisture imbibed. Mr. Woodward found that a sprig of mint in 77 days, absorbed 2558 grains of water, and yet its weight was only increased 15 grains. Another branch absorbed 14190 grains, and had its weight only increased 128 grains. Dr. Hales found that a cabbage transpired daily a quantity of water equal to half its weight, and that a sun flower three feet high transpired in a day 1lb. 14oz. He shewed that the quantity of perspiration in the same plant was proportionate to the surface of the leaves, and that when the leaves were taken off, the transpiration ceased. He found too that the transpiration was nearly confined to the day, that very little took place at night, or in cold and wet weather, and that the sun much promoted it. On collecting and examining the matter transpired, he found it to be nothing more than water with a little of the odour of the plant.

The leaves appear to have particular organs adapted for throwing off part of the sap by transpiration, and these appear to be on the upper surfaces of the leaves, as the transpiration is almost entirely stopt when the upper surfaces are varnished over. Gradually the leaves become unfit for this process, and then they drop off in the fall of the year.

The first great change then which takes place upon the sap after it arrives at the leaves, is the evaporation of a great part of it, and consequently what remains of it must be changed in its proportions.

Further changes are also wrought. Dr. Priestly made the important discovery, that the leaves had the power of decomposing carbonic acid, of uniting to its carbon and of leaving the oxigen in a state of purity. When this oxigen or vital air was first observed to escape from plants, it was supposed that plants had the capacity to give out vital air, which supplied the place of that consumed by animals. But this was a mistake, and has been proved to be so, by the indefatigable chemist, Dr. Woodhouse of Philadelphia. He found that plants immersed in pure water, which had been distilled, did not give out oxigen; but when pump water was used, or any water which contained carbonic acid, then oxigen air was formed in consequence of the plants depriving the air of its carbon. Moreover, it has been shown that plants do not vegetate unless carbonic acid be present. If they be put in air deprived of all this acid, they vegetate for a short while, in consequence of their parting with a little of their carbon to unite to the surrounding oxigen to form the carbonic acid, which then serves to nourish them. But if quicklime be around them, which absorbs the acid as fast as it forms, they do not vegetate.

Plants in all probability acquire most of their carbon by decomposing carbonic acid. This decomposition chiefly goes on during the day, when the action of the sun has great influence. The green color of the leaves depend entirely on their vegetating in the light. For as observed while considering light, this color will be entirely lost in all plants, if they be included in boxes, or in any thing which will prevent the contact of light.

The sap besides losing water when brought to the leaves, uniting to carbon, and being acted on by the light, undergoes other changes. During the night they absorb oxigen as has been stated very evident by Dr. Ingenhousz; who also ascertained that they grew very well in oxigen air, and that they emitted carbonic acid which afterwards served for nourishment. They also absorb moisture from the atmosphere. The great effects which dew, slight showers of rain, and even wetting the leaves of plants, have in increasing the vigor of plants, has been long observed. That they imbibe moisture, was made nearly certain by Dr. Hales, who found that the plants increase considerably in weight when the atmosphere is moist. Mr. Bonnet put this beyond all doubt, by discovering that the leaves continue to live for weeks when one of their surfaces is applied to water; and that they not only vegetate themselves, but imbibe enough water to support the vegetation of a whole branch, and the leaves belonging to it. The absorption chiefly takes place at the under side opposite to that on which the transpiration goes on.

It must appear, that the perspiration, the absorption of carbon, oxigen and moisture, and the action of light produces very important changes on vegetables. We will now consider the nourishment received by other parts of the plant, namely the roots.

It has long been known that the roots of plants perform most important offices, and indeed it was supposed formerly that it was only by the roots, that nourishment was received. This nourishment must be the elements before named, which are found in vegetables when decomposed. But these elements are not afforded in the simple or uncombined state. We shall examine the state in which the food is absorbed.

In the first place, it is certain that plants will not vegetate without water, for whenever they are deprived of it they wither and die. Hence the well known use of rains and dews. Water then is at least an essential part of the food of plants. Many plants grow in pure water, and in consequence of this Van Helmont, Boyle and others have maintained that it was the sole food of plants. But this requires no further refutation than the fact, that elementary substances are found in plants which are not found in water. Moreover, in general it is only a *certain* proportion of water which is serviceable to plants, and too much of it proves as destructive as too little. The greater part of them are entirely destroyed when immersed in that fluid beyond a certain time. Hence, different soils are necessary for the proper growth of different plants. Rice, for instance, requires a very wet soil: when it is sown on the ground where wheat grows luxuriantly, it will not grow; and, on the contrary, wheat will rot instead of vegetating in rice fields.

Almost all plants grow in the earth, and almost every soil contains at least three or four of the elementary earths, called alumine, silex, lime, and magnesia. The chief use of these earths is to administer, as it were, the proper quantity of food to the plants; at least, they afford a kind of bed in which the roots attract those substances they require. Moreover, they serve to collect food: for, it is an unquestionable fact, that soils absorb, at least when opened, considerable quantities of airs from the atmosphere. They generally absorb oxigen air and carbonic acid, each of which proves useful to vegetables. Hence the advantage of deeply ploughing land, and leaving it at rest for this absorption to take place. The earths are also useful in other respects. But few plants are met with which do not contain more or less of them; and it is reasonable to suppose that at least they form a small part of the food of the plant.

Besides water and the earths, carbon is necessary for the growth of plants. It forms a most important part of nearly every vegetable. From a great variety of experiments, it has been ascertained that the quantity of carbon in fertile soils is very great. *Generally* it is to this that they owe their dark color. Fourcroy and others, by various examinations have found, that at least one sixteenth of good soils consists of carbon. It does not, however, exist in a state of purity. Large quantities are combined with oxigen, in the form of carbonic acid, which is also united to some other substance. The fertility of soils may generally be judged of by the quantity of carbon they contain. To judge of this quantity, the soil should be inclosed in a retort, to which a little nitre is added, and exposed to a strong heat. The air which comes over should be preserved by means of the pneumatic apparatus; and the quantity of carbonic acid will give an idea of the quantity of carbon. It is scarcely necessary to observe, that in this experiment the oxigen of the nitre unites to the carbon and forms fixed air. Perhaps, nitric acid would answer better than nitre. The carbon, however, is of no use if it exist in that solid state, as in diamond and pit coal, in which the power of the vegetables is not sufficient to destroy its cohesion.

Many plants also require a portion of nitrogen. The state in which they unite to it is not known. Perhaps, they take it from the water; perhaps, they take it from the remains of dead animals; or, perhaps, they take it from nitre. All these substances must exist in proper proportions, otherwise the plants will not thrive. An excess or deficiency of either is injurious.

But without heat plants will not vegetate in any mixture. Below the freezing point none of them increase in bulk. Every plant seems to require a degree of heat peculiar to itself, at which it commences and continues to grow. Hence, each seed has a particular season at which it begins to germinate, and this season varies with the temperature of the air. Hence, the same seed sown at the same time in different countries vegetate differently.

Such being then the food of plants, and such the circumstances in which it is taken, we will proceed to consider the art of improving soils, by which is meant, rendering them more capable of supporting vegetation.

In the first place, it must appear very evident that great attention should be paid to the nature of the plant to be cultivated. Should it be one of the kind requiring much water; and should the country not be subject to frequent showers, then a soil calculated for the retention of moisture is to be chosen. Such soils are those of the clay kind. They contain great quantities of alumine; and while considering this elementary earth, it was observed that it was remarkable for the quantity of water it was capable of retaining. These are called *wet soils.* The soils containing much sand, or silicious earths, are of an opposite nature, and are consequently called *dry soils.* The soils containing lime and magnesia, are intermediate between these extremes; they render a sandy soil more retentive of moisture, and diminish the wetness of a clayey one. By bringing, therefore, together the proper proportions of these earths, we may form a soil of any degree of dryness or moisture we please. While, however, we are considering this, we must not lose sight of the *power* or *strength* of the roots, by which they are enabled to penetrate and spread about in the earth. This power, in some instances, is so inconsiderable, that the roots are confined to a very small space. In such cases, some light substance is necessary, which so diminishes the solidity of the clay, that the roots can grow in any direction. But the selection of a soil must, after all, be much regulated by the quantity of rain which usually falls in the place. If but little rain falls, the soil, however retentive of moisture, must remain dry; and if rain falls very frequently, the soil must be *very* open if it be not constantly wet. In a rainy country the soil ought to be open, or contain a large proportion of sand; and in dry situations, there ought to be great quantities of clay, which is retentive of moisture. Lands on a plain should also, under the same circumstances, be more open, or contain more sand than those on hills.

But the chief means by which soils are generally improved, depend on the addition or mixture of certain articles, called *manures*.

Concerning the *kinds* and the nature of manures, philosophers and farmers have long differed. The first have disputed much, and the practices of the second have not less clashed. These differences, however, are now fast subsiding; and a few simple truths have been established, by which all apparent contradictions may be explained; and the art of improving land may rapidly progress.

The art of improving land, so as to promote vegetation, may be considered as depending on these causes. The *first*, is the application of such substances as stimulate the vessels of the plant (or increase their action) so that they unite to parts of the soil with greater rapidity. The *second* is the application of such substances to the earth, as convert the bodies in the earth, into that state in which they favor vegetation: Such might be called *solvents*. And the *third*, is the application of such bodies to the earth, as enter into the composition of the growing plants.

Of the substances which operate in the first way: namely, by increasing the action of the parts of the plant, there are but few known. Heat, light, and electricity are almost the only kind. From Professor Barton's experiments, camphor appears to operate in a similar way.--- Diluted ardent spirit will have, I believe, a similar effect. But perhaps, it will never be an object to apply such substances to vegetables; excepting heat, which is sometimes applied, particularly by means of the *hot-beds*, formed by putrefying manures.

Of the substances acting in the second way: namely, by decomposing bodies in the earth, so as to adapt them for becoming food to the plants, there are also but few. They operate in such a manner, as to excite a kind of putrefaction in the compounds containing the elements of the growing vegetables. For example, a soil may contain roots, which not having putrefied, do not aid vegetation. Now all substances which will cause or hasten the putrefaction of such bodies, are to be ranked under this head. The substances acting in this way, are a small quantity of common salt, and a small quantity of the plaster of Paris, each of which in small proportions are found to expedite putrefaction very much. In some instances they no doubt operate as manures, differently. Besides these, it is universally known that heat, moisture, and air, have great influence in hastening putrefaction. But the value of these is somewhat lessened, as they carry off a part of the matter after it has putrefied. However such kinds of substances must be of unquestionable value, as the bodies contained in the earth might as well not be there, if they be not in a state in which they are capable of uniting to the vegetables; and thereby promoting their growth.

But the most important *manures* operate in the *third* way: namely, by imparting to the soil, the particular kind of matter best suited for entering into the composition of growing vegetables. Of this kind the most remarkable are pit and charcoal, reduced to a fine powder; the manure of animals, as well as their putrid bodies and pounded bones; ashes; putrid vegetables, particularly those of the saline kind, such as tobacco, weeds, &c. lime, plaster of Paris, chalk, the strong diluted acids, and, in fine, all substances containing either hidrogen, oxigen, carbon, or nitrogen, in such a loose state that the plant can attract and unite to them.

To the reflecting world it has long been a subject of astonishment, that small quantities of these various manures, frequently tend, in a great degree, to favor vegetation; so that, in some instances, one hundred pounds of a manure, will produce an increase of vegetation in one year, equal to 10,000 weight. But on examining the subject, we find less cause for wonder.

We know that for the growth of a plant, certain proportions of certain elements, are indispensably necessary. Without any one of these constituents, the rest cannot perform their part. Suppose that for the formation of a cabbage it was necessary that there should be five pounds of water, two of carbon, and one ounce of nitrogen. The water and the carbon could be of no service, unless the nitrogen were present. Now on adding a little nitrogen, the plant instantly united with it, and in consequence exercised its power to combine with large portions of water and carbon, so as to increase to a great bulk. In this manner manures act. They yield to the vegetable that something which the soil does not contain in abundance, and in consequence of this the vegetable is enabled to combine with large quantities of its other constituent parts, which exist either in the earth or in the surrounding atmosphere. They resemble animals in this respect. It is well known that all the food a man can swallow is of no service to him unless he can also have a few grains of vital air in his lungs.

It may not be amiss to make some remarks concerning a few manures which claim particular attention, and first of

PIT COAL.

WHEN considering this article in another place, I stated that in a given bulk it contained a great quantity of carbon; a substance which enters into the composition of almost every vegetable, and which forms more than half the body of half the products of the vegetable kingdom. Now as carbon must enter into the composition of the domestic plants, it must be of service in improving soils. But it has been stated that before carbon can enter into plants, it must be in a certain state, in which, according to some, it may be dissolved in water, to be applied to the roots of plants. Hence they have inferred, that as pit coal is not soluble in water, so it cannot be of service to the roots of vegetables; and this has been supported by a few experiments made by different persons with the coal, by which it appeared to be of little or no use. Being forcibly struck with the quantity of carbon in this coal, I thought it very surprising that it was not found to be a manure. This led me to institute several experiments, relative to the subject, an account of which was published in most of the public prints some months since. The result of these experiments prove that coal is one of the most valuable manures, ever applied to land. While conducting these experiments I was conscious that the *cohesion* of coal was too strong to be overcome by the powers of the plant. This led me to provide against this, by reducing the coal to a most impalpable powder, previous to mixing it with the earth. When this was done, the coal accelerated the vegetation of wheat and corn with astonishing facility. However, from my experiments, I am unable to say what quantity is necessary for an acre of land. But these experiments made it unquestionably appear

1ſt. That those who experimented with coal, did not reduce it to a very fine powder.

2d. That coal in the state of a coarse powder is no better than common sand, as vegetables have not the power to decompose it.

3d. That coal reduced to a powder as fine as wheat flour, will unite to plants and act as a most excellent manure for all plants requiring carbon for their growth.

4th. That great good would be derived if mills were erected for reducing coal to the state of a fine dust, as the coal could be had very cheap, from the immense mines found throughout the country, and the lands enriched at no great expense.

CHARCOAL.

AN eminent agriculturist, Mr. Young of England, appears to have been the first who found that common charcoal was a good manure. For it, however, to operate as a manure, it must be reduced to the state of a fine dust.

Like pit coal, in the compact state, it is of no use. Since it is an excellent manure, it must appear very erroneous to have it wasted by fire, in many poor countries, unnecessarily. To avoid this, it would be of consequence to have wood converted in the new grounds into coal; then it might at leisure be made into dust, and sprinkled on poor lands. Now as peach trees grow well in poor lands, and as they contain much carbon, would it not be advantageous to have them planted in vacant ground, and then after they ceased to yield fruit, have them reduced to the state of charcoal and sprinkled on the earth, to prepare it for other uses.

LIME.

THIS has, under many circumstances, been found an excellent manure. It no doubt acts in three ways. In one it serves to absorb water and yield it for plants; in another to unite itself to them; and in a third to absorb carbonic acid from the air, and from the compound

CHALK;

OR

CARBONATE OF LIME.

THIS has long been found to be a manure. In all probability it acts by parting with its carbon of its acid to the plant; or its oxigen. Burnt bones act in the same way.

PLASTER OF PARIS;

OR

SULPHATE OF LIME.

—

IT has not been long since this compound was used as a manure. When reduced to a powder, three or four bushels of it to the acre, appear to increase remarkably the fertility of some soils. In the first instance, it no doubt acts by hastening the putrefaction of the dead vegetable matter. In the second instance, it probably is useful, by imparting to the plants oxigen, which is contained in considerable quantities in the sulphuric acid, which is one of its constituents. On the same principle it has been found that a small quantity of sulphuric acid is of remarkable utility to plants; also saltpetre, and indeed all the substances containing oxigen or carbon. Hence water, impregnated with oxi-muriatic acid, is found to quicken vegetation, as well as when mixed with carbonic acid. Hence the water passing through dung heaps, which is impregnated with coal and all the saline parts of the mass, is found to act as a powerful manure. Hence sawdust, roots of plants, chips, sticks, straw, &c. on ground are of no manner of service, until their cohesion is so completely destroyed, by putrefaction, that the powers of the living plants are sufficient to attract and combine with them.

However, in the application of manures, the agriculturist should always have in view the making *a due proportion* of the constituents of his soil. Too much of any substance will prove injurious; particularly too much of saline substances, as salt, nitre, &c. On calculating the advantages derived from manure, he should also be aware, that much of the future growth of plants depends on their early progress; that considerable *parts* of the body of plants are derived from the air, consequently that manures are the more valuable, as they enable vegetables to grow; to attract substances, water and carbon particularly, from the atmosphere; which, when the plants decay, are mingled with the soil, whereby it becomes much improved.

DISCOURSE XIII.

THE next important, and indeed the only remaining bodies which present themselves for our consideration, are those formed in the animal kingdom. Decomposition by means of heat, will shew that these substances are composed chiefly of nitrogen, hidrogen, oxigen, carbon, phosphorus and lime, with small portions of iron, potash, soda, sulphur, latent heat and light, and in some instances one or two other elementary bodies. But such a kind of decomposition being of no use, we will not take it into consideration, and will proceed to treat, first, of a few remarkable substances, found in considerable quantities in animals, which may be termed their *proximate principles.* They are known by the following names:

1. Gelatine, or animal jelly.
2. Albumen, or a substance like the white of eggs.
3. Fibrina.
4. Oils, or fat.

GELATINE.

THIS is a substance which exists in many parts of animals. It may be procured by the following means:

Take a piece of the fresh skin of an animal, such as an ox; separate the hair from it, and wash it in cold water until the liquid ceases to be colored. If the skin thus purified, be put into a quantity of pure water, and boiled for some time, part of it will be dissolved. Let the decoction be slowly evaporated till it is reduced to a small quantity, and then put it aside to cool. When cold, it will be found to have assumed a solid form, and to resemble precisely the substance known to all under the name of *jelly*. This is the substance called in chemistry *gelatine*. If the evaporation be still farther continued, by exposing the jelly to dry air, it becomes hard, somewhat transparent, breaks with a glassy fracture, and is, in short, the substance so much employed in different arts, under the name of *glue*. Gelatine, then, is precisely the same substance as glue; only we must suppose it free from those impurities with which glue is always mixed.

Gelatine is nearly colorless when pure. Its consistence and hardness vary considerably. The best kinds are very hard, brittle, and break with a glassy fracture. Its taste is insipid, and it has no smell. When thrown into water it swells, but does not dissolve; when taken out it is soft; and on drying recovers its appearance. If in this state it be put into warm water, it very soon dissolves and forms a solution. In this state it very soon putrefies; an acid makes its appearance; a fetid odour is exhaled, and afterwards ammonia is found.

The acids dissolve gelatine, but the changes they produce on it are not known. It is insoluble in ardent spirit. It is most remarkable for its combining with the vegetable substance *tannin*, and forming with it an insoluble compound, of which mention was made while considering the tanning of leather. When a solution of tannin is added to gelatine, a copious precipitate soon appears, of a white color, and somewhat resembling vegetable gluten. This compound dries in the open air, and forms a brittle, resinous like substance, not susceptible of putrefaction, and resembles over tanned leather. The precipitate is, however, soluble in a solution of gelatine.

Gelatine, like all other constituents of animal bodies, is susceptible of numerous shades of variation in its properties, and of course is divisible into a number of species. Several of these have been long known and manufactured for different purposes, among which are the following.

COMMON GLUE.

THIS has been long manufactured in many countries, and employed to connect pieces of wood together. It is extracted by water from animal substances, and differs in its qualities according to the substances employed. Bones, muscles, tendons, ligaments, membranes and skins all yield it; but that of the best quality is obtained from skins, and those too of the oldest animals. The parings of hides, pelts, the hoofs and ears of horses, cows, sheep, &c. are the substances from which it is usually extracted. They are first digested in lime water to clean them, then steeped in clean water, laid in a heap till the water runs off, and then boiled in large metallic vessels with pure water. The impurities are skimmed off as they rise; and when the whole is dissolved, a little alum or finely powdered lime is thrown in. The skimming having been continued for some time, the whole is strained through baskets and allowed to settle. The clear liquor is gently poured back into the kettle, boiled a second time, and skimmed until reduced to the proper consistence. It is then poured into large frames, where, on cooling, it concretes into a jelly. It is in this state cut by a spade into square cakes, which are again cut with wire into thin slices and exposed to the air to dry. The best glue is extremely hard and brittle, has a dark brown color, and no black spots: when it is soluble in cold water it is a proof that it wants strength.

It may not be unnecessary to remark that the skins which dissolve most readily in boiling water afford the most glue; so that the most supple hides yield the weakest glue, which is very soon obtained from them by hot water. The skin of the eel is very flexible, and affords very readily a great proportion of gelatine or glue. The skin of the shark also yields it readily and in abundance: and the same is observed of the skins of hares, rabbits, calves, and oxen. The difficulty of obtaining the glue, and its goodness always increases with the toughness of the hides. The hide of the rhinoceros, which is exceedingly strong and tough, far surpasses the rest in the difficulty of solution, and in the goodness of the glue. When skins are boiled they gradually swell and assume the appearance of horn, then they dissolve slowly.

SIZE.

THIS substance differs from glue in being colorless and more transparent. It is manufactured in the same way, but with more care. Eel skins, vellum parchment, some kinds of white leather, and the skins of horses, cats and rabbits, are the substances from which it is usually procured. It is employed by paper makers to give strength to paper, and likewise by linen manufacturers, gilders, polishers, &c.

ISINGLASS.

THIS substance is like size in transparency, but it is much finer, and is therefore employed as an article of food. It is prepared from the air, bladders and sounds of different kinds of fish, which are found in the mouths of large rivers. The bladder is taken from the fish, washed clean, the exterior membrane separated, cut lengthwise, formed into rolls, and then dried in the open air. When good, it is of a white color, nearly transparent and dry. It dissolves in water with more difficulty than glue, and it is soluble in ardent spirit.

A coarse kind of isinglass is prepared from sea wolves, sharks, cuttle fish, whales and all fish without scales.--- The head, tail, fins, &c. of these are boiled in water, the liquid skimmed and strained, and again boiled till of the proper consistence. It is then cast on flat boards and cut. This species is used for clarifying, for stiffening silk, making sticking plaster, &c.

GELATINE exists in great abundance in animals. It forms a part of their solids and fluids. Blood and milk contain it always. It forms an essential part of bones, ligaments, tendons, muscles, hair, skin, &c.

Its uses are very numerous. In the state of *jelly* it constitutes one of the most nourishing and palatable species of food. It is the basis of soups. The great variety of purposes to which it is applied in the state of glue, size and isinglass are well known.

II. OF ALBUMEN.

THIS is a substance which exists nearly in a state of purity in the *white* of an egg, and in that part of blood which remains fluid after it rests for some time, and is called the *serum*. When heated to 165°, it coagulates, or in other words, loses its fluidity, and then becomes of a white appearance. It is also coagulated when any of the strong acids or ardent spirit is mixed with it. This property of assuming the solid state, (or coagulating) by the exercise of its affinities, in the state created by the above heat, is characteristic of albumen.

When albumen is coagulated, it is insoluble in water, and its tendency to putrefy is lessened. Some other of its properties are also changed.

Fluid albumen is soluble in water. It appears as a glary liquid, having little taste and no smell. When dried in the air, or by a slow heat, it becomes a brittle, transparent, glassy like substance; which when spread thin upon plain surfaces forms a varnish, and is accordingly employed by book binders for that purpose. When thus dried, it has a considerable resemblance to gum arabic, to which also it is similar. The white of an egg loses about four fifths of its weight in drying. It continues after this drying soluble in water as before. In this state, it resists putrefaction much more than in the fluid state. It unites to tannin like jelly, forming an insoluble compound. Mixed with a small quantity of lime, (particularly the white of an egg) it forms an excellent lute, which is frequently used to connect together broken plates, &c.

Like all other animal substances, albumen is capable of existing in various states, both when solid or fluid. It forms an essential part of bone and muscle; and the brain may be considered as a species of it. Nails, horns, hair, cartilage, &c. are in great measure composed of it; and it forms the membranous parts of many shells, sponges, &c. And, in short, it is one of the most important of the animal substances.

The property which albumen has of being coagulated by heat, renders it a very useful substance for clarifying liquids. The serum of blood, white of egg, or any liquid containing it, is mixed with the liquid to be clarified while cold, and then the whole is heated. The albumen coagulates, and carries down with it the floating particles which rendered the liquid opaque. It is on this principle that the whites of eggs are added to coffee.

III. FIBRINA.

THIS is the name of a substance of great importance in animal bodies. It may be had in a state of purity by the following process: take a quantity of blood, newly drawn from an animal, and on allowing it to rest for some time, a thick red clot gradually forms in it, which is generally called the *coagulum*. Separate the clot from the rest of the blood, put it into a linen cloth and wash it repeatedly in water till it ceases to give out any color or taste to the liquid; the substance then remaining will be of a white appearance, and is that which chemists call *fibrina*. It has been long known to physicians under the name of the *fibrous part of the blood*, or *coagulating lymph*.

Fibrina is of a white color, has no taste or smell, and is insoluble in water and ardent spirit. When newly extracted from blood, it is soft and very elastic, and strikingly resembles the gluten of vegetables. It undergoes no change though kept exposed to the air; nor does it speedily alter if kept under water.

When exposed to heat, it contracts very suddenly, and moves like a bit of horn, emitting at the same time a smell like that of burning feathers. In a strong heat it melts, and in an intense heat it is entirely decomposed.

Fibrina exists only in the blood and muscles of animals; but there are great varieties of it, as must appear from the variety in the muscles of fish, fowl, quadrupeds, and other kinds of animals.

IV. OILS.

THE oily substances found in animals, in some respects resemble those obtained from the vegetable kingdom, and called expressed oils. They differ very much in their consistence from each other, being found in every intermediate state from spermaceti, which is perfectly solid, to train oil, which is completely liquid. The most important of these are the following.

1. SPERMACETI.

THIS substance is found in a fish called the spermaceti whale, and also from others. At first it is mixed with some liquid oil, which is separated by means of a woollen bag. The last portions of this oil, are separated by means of a solution of potash or soda in water; and the spermaceti is then purified by fusion. Thus obtained, it is a beautiful white substance, usually in small scales, very brittle, has scarcely any taste, and but little smell. It is distinguished from all other fatty bodies, by its appearance in the state of crystals. In a heat of about 112° degrees it melts. When sufficiently heated, it may be distilled over without much alteration; but when distilled repeatedly, it loses its solid form, and becomes a liquid oil. It is soluble in boiling alcohol, but separates again as the solution cools;

about 150 parts of ardent spirit are necessary for its solution. Ether dissolves it cold, and very rapidly when hot; when cooling, the whole concretes into a solid mass. It is dissolved also in the hot oil of turpentine; but is deposited as the liquid cools.

When long exposed to the air, spermaceti becomes yellow and rancid. In this case it may be purified, by breaking it into small pieces, and exposing it to the combined action of the sun and air for some time, by which it loses a great deal of its smell, and acquires a firm consistence. It should then be reduced to powder, and a weak solution of nitrous acid should be poured on it; in an hour a froth is formed, and the acid is decanted, and the substance repeatedly washed, then melted in hot water, and when cool, it appears of a beautiful straw color, and has the agreeable smell of the best spermaceti.

This substance is very inflammable, and is employed like wax and tallow, for making candles. It was at one time much used as a medicine, particularly in breast complaints. It is said, that if bits of elastic gum be added to it while melted, the gum is dissolved, and the compound answers remarkably well for luting vessels together.

2. FAT.

THIS substance is found abundantly in different parts of animals. When pure, it possesses the properties of the thick oils. Its consistence varies from *tallow* or *suet*, which is brittle, to *hog's lard*, which is soft. To obtain fat pure, it is taken from animals; cut in pieces; well washed in water, and the membranous parts and vessels separated. It is then melted in a shallow vessel along with water, and kept melted till the water is completely evaporated. Thus purified, it is white, tasteless, and nearly liquid.

Different kinds of it liquify at different temperatures. Hog's lard melts at 97° ; but, the fat extracted from meat boiling, requires, according to Nicholson, a heat of 127° : when heated to about 400° it begins to emit a white smoke, which becomes more copious and more disagreeable as the heat increases ; at this time it becomes black, owing to a decomposition of a portion of it, and the deposition of some charcoal. If it be now cooled it becomes more brittle and solid than the first.

Fat is insoluble in water, alcohol, and ether. The strong acids dissolve and gradually decompose it. With the alkalies it combines and forms *soap*, as was stated while considering the alkalies.

On distilling fat there is obtained from it an acid of which we have spoken, called the *sebacic acid.* This acid exists in fat in such a state of combination that its presence cannot be detected. It is stated that the solidity of fat depends on this acid. When the fat is kept in a warm place, it undergoes changes by which it becomes rancid. This rancidity is stated to arise from the disengagement of the sebacic acid; and this acid is also supposed to be formed in consequence of the absorption of oxigen from the air by the *mucilage* which most fat contains. However, be this correct or not, the rancidity may be corrected by mixing the fat well with large quantities of hot water, or ardent spirit: cold water impregnated with carbonic acid and powdered charcoal are said to have the same effect. Marrow differs very little in its nature from fat.

III. TRAIN OIL.

THIS liquid is extracted from the blubber of the whale, and from other fish. It forms a very important article of commerce, being employed for combustion in lamps, and for other purposes. It is at first thick, but on standing, a white mucilaginous matter is deposited and the oil becomes transparent. It is then of a reddish brown color, and has a disagreeable smell.

Various methods have been employed for purifying train oil. The purification can be effected by agitating it with a little sulphuric acid, and then adding a little water. The oil when allowed to settle swims on the surface, of a much lighter color than before, the water appears milky, and a turbid matter is observed swimming between the oil and water.

Spermaceti oil. This is the oil which is separated from spermaceti during its purification. It is much purer than train oil, and, therefore, answers better for lamps.

IV. ANIMAL OIL OF DIPPEL.

THIS is an oil once of great celebrity among the ancients. It is usually called as above. It is obtained by the distillation of the soft parts of animals, and also from horns. The product of the first distillation is to be mixed with water, and distilled with a moderate heat again.

This oil is colorless and transparent; its smell is strong and rather aromatic. It is almost as light and volatile as ether. The alkalies unite to it, forming soap; nitric acid sets it on fire. It was formerly used as a remedy for fevers. It contains a little ammonia, in consequence of which, it changes blue vegetables to a green.

ALMOST the whole of the soft parts of animal bodies consist of the substances we have described; namely, gelatine, albumen, fibrina and oil. However, there have been found several other substances, which must be considered, although they have not been found in considerable quantities. The most remarkable are the following.

AMBERGRIS.

THIS is a substance found floating on the sea near the coasts of India, Africa and Brazil, usually in small pieces, but sometimes in masses of 50 or 100 pounds weight. Various opinions have been entertained concerning its origin. Some have affirmed that it was the concrete juice of a tree; others thought it a bitumen; but it is now generally considered as a concretion formed in the stomach or intestines of the spermaceti whale.

Ambergris when pure, is a light soft substance which swims on water. Its specific gravity is about 0.845. Its color is ash grey, with brownish, yellow and white streaks. It has an agreeable smell, which improves on keeping. Its taste is insipid. It is insoluble in water. Both the fixed and volatile oils, and also ether and alcohol dissolves it.

CASTOR.

THIS substance is obtained from the beaver. In the groin of that animal, there are two bags, a large and a small one. The large one contains the true castor. When first procured it is nearly fluid; but by exposure to the air, it gradually hardens, becomes darker colored, and assumes a resinous appearance. Its taste is bitter and acrid, and its odour strong and aromatic. It is used as a perfume.

CIVET.

THIS substance, like the last, is obtained from the groin of the *civet cat*. It is squeezed out of the cavity where it is secreted every other day. It is employed as a perfume, but has not hitherto engaged the attention of chemists. Its color is yellow. Its consistence that of butter; and its smell is so strong that it is only agreeable when reduced by mixture with other bodies.

MUSK.

THIS substance is secreted in a kind of bag, situated about the navel of a quadruped, called *muschus maschifer*. Its color is brownish red. It feels greasy. Its taste is bitter. Its smell aromatic and very strong. It is soluble in ardent spirit, but it then loses its odour. It is partially soluble in water, and it then retains its odour. At a red heat it smells like urine. It is chiefly used as a perfume, and as a medicine. In hysteric and other nervous affections, it is given in repeated doses of three or four grains.

SUGAR.

SACHARINE matter has frequently been found in the fluids of animals; not however in the state of common sugar. This animal sugar, if it may be so called, is found in milk, and in the urine of persons laboring under a disease called *diabetes*.

SUGAR OF MILK

MAY be obtained by the following process: Let fresh whey be evaporated to the consistence of honey, and then allowed to cool. It concretes into a solid mass. Dissolve this mass in water, clarify it with the white of eggs; strain it and then evaporate it to the consistence of a syrup. On cooling, it will deposit a number of brilliant white crystals, which are *sugar of milk*.

When pure, it has a white color, a sweet taste, and no smell. Its specific gravity is 1.543. At a temperature of 55 it is soluble in seven times its weight of water; but it is perfectly insoluble in ardent spirit. When burnt it exhibits the same appearances as common sugar, and by distillation the products of each are found nearly the same.

SUGAR OF URINE

MAY be obtained, by collecting considerable quantities of the urine of persons laboring under the disease called diabetes, and evaporating it to the consistence of honey, as above. Mr. Cruickshank extracted from some diabetic urine one twelfth its weight of a sweet tasted extract like honey. When heated with nitric acid, it yielded the same products that common sugar did. But it could not be made to crystallize, and when added to lime it is decomposed, which is not the case with common sugar.

Besides the substances above named, several others have been obtained from various animals, particularly of the insect tribe, which are distinguished by remarkable properties. *Cantharides*, or Spanish flies, are among the most important. This insect, when rubbed up and applied to the body, is universally known to excite irritation and blisters. This is the property by which they are distinguished.--- When taken internally, they operate very violently in small quantities, and appear to produce a particular determination to the urinary organs. However, in small quantities, dissolved in ardent spirit, (forming the tincture of cantharides) they form an useful medicine. There is a bug common in this country, and which is found particularly about potatoe vines, very much like the Spanish fly in its effects on the body. It is substituted for the fly in many parts, and from the cost of the fly, it is hoped that this practice will become general. This bug can be collected in bottles, and kept for use.

The article of commerce sold by the term *cochineal*, is also an insect obtained chiefly from Mexico and St. Domingo. It is dried, and preserved for the use of dyers, as is universally known. *Lac*, or *gum lac*, is also an animal substance, collected by red winged ants in the East Indies. It is used in coloring sealing wax, and other bodies. But it is not consistent with the plan of this work, to enter into a particular detail of such substances.

The following acids have also been obtained from the animal kingdom. As they are not of much consequence, it will be useless to dwell on them.

1. PRUSSIC ACID.

OF this we stated all that was of any consequence when considering its combination with iron, forming the *prussiate of iron*, or Prussian blue. The acid, as before observed, is formed by the decomposition of animal parts with potash in a strong heat. Its combination with other substances, forming *prussiates*, have not been attentively examined, and it is difficult to form them.

2. LACTIC ACID.

THIS acid exists in the whey of milk. On evaporating the whey, its taste will be perceptible. With other bodies it forms *lactates*, of no known importance.

3. SEBACIC ACID.

THIS acid is obtained by the distillation of hogs lard with hot water. The acid comes over. When it unites to other bodies, it forms compounds, called *sebates*.

4. URIC ACID.

THIS acid is obtained from human urine: it also exists in the calculi obtained from the bladder, and from gouty concretions. It is scarcely soluble in water: it may readily be decomposed by a strong heat. It unites to other substances, forming *urates*, which are of no known value. However, it has been ascertained, that the calculi of the urinary bladder are very generally composed of a little mucilage with the urate of potash or soda. The urate of soda also forms the concretions found in persons affected with gout; these were commonly called *chalky* concretions, in consequence of their being mistaken for preparations of lime. It is to Drs. Wollaston and Pearson that we are indebted for this information.

5. AMNIOTIC ACID.

THIS is obtained by evaporating the fluid which surrounds the calf in the womb of the cow. It has not been much attended to, as well as several other acids, such as the *bombic acid*, said to be obtained from the silk worm, and the formic acid, said to be obtained from ants.

THE various bodies which compose animal parts, have been commonly arranged under the two heads of *hard parts* and *soft parts*. The hard parts of animals are principally the following: *bones*, *horns*, *nails*, *muscles*, *skin*, *membranes*, *tendons*, *ligaments*, *glands*, *brain*, *nerves*, *hair*, *feathers*, *and silk*; of which we will treat in the order in which they are named.

OF BONES.

THE bones are the most solid parts of animals; their texture varies according to the situation of the bone. They are white, appear to be formed of *plates*, and cannot be softened by heat. Their specific gravity differs in different parts. That of adults' teeth is 2.2727: the specific gravity of children's teeth is 2.0833. It must have been always known that bones are combustible; and that when sufficiently burnt, they leave behind them a white porous substance, which is tasteless, absorbs water, and has the form of the original bone.

The component parts of bone are chiefly four: namely, the earthy salts, fat, gelatine and cartilage.

1. The earthy salts may be obtained, either by burning the bone till it becomes white, or by steeping it in acids. In the first case, the salts remain in the state of a brittle white substance. In the second, they are dissolved by the acids, and may be precipitated by adding an alkali. These earthy salts are three in number: 1, the phosphate of lime, which constitutes by far the greatest part of the whole: 2, carbonate of lime, or chalk: 3, sulphate of lime, which is found in much the smallest quantities.

2. The proportion of fat contained in bones is not less various. By *breaking the bones in small pieces* and boiling them for some time in water, this fat will be found swimming on the liquid. It is stated, that by these means one fourth of the weight of the bones will be found to be fat. This is a much larger quantity of fat than is commonly had

from them, and in all cases it must appear, that it would be found of advantage to break the bones before boiling them.

3. The gelatine is separated from bones by the same means as the fat, by breaking the bones in pieces, and boiling them long enough in water. The water dissolves the gelatine; and when evaporated in part, it is converted into a jelly. Hence the importance of bones in making portable soups and glue, the base of which is gelatine. About one tenth of the weight of bones is found to be gelatine. It is stated that pounded bones, long boiled, will make as good soup as four times their weight of flesh; or if they be not pounded, they should be boiled in Papin's digester.

4. When bones are deprived of their fat and gelatine by boiling them in water, and of their earthy salts by steeping them in diluted acids, there remains a soft, white, elastic substance, possessing the figure of the bones, and known by the name of cartilage. This substance is found to be nothing more than coagulated albumen; brittle and nearly transparent when dried; soluble in hot water, and is converted into jelly on cooling.

This cartilaginous substance is the portion of the bone first formed. Hence the softness of the bones of young animals. The phosphate of lime is afterwards gradually deposited, and gives the bones the requisite firmness. The gelatine and fat, especially the first, give the bone the requisite degree of toughness and strength; for when they are removed the bones become brittle. The relative proportion of phosphate of lime and cartilage differ in different bones, and in different animals. The only part of a bone found destitute of cartilage, is the enamel of the teeth.

However the teeth of adults is found generally composed as follows:

64	parts	phosphate of lime,
6	do.	carbonate of lime,
20	do.	cartilage,
10	do.	loss.
100		

The bones obtained from a great way beneath the earth, are called *fossil* bones. According to Dr. Hatchett's examination of those procured from Gibraltar do not contain any cartilage, or soft animal part. Their cavities are filled with the carbonate of lime. Hence, they resemble bones which are burnt. Putrefaction does not destroy the cartilaginous part of bones: hence, Mr. Hachett found, on examining bones taken from a Saxon tomb, that they contained as much cartilage as fresh bones. Now, in consequence of this, it is exceedingly probable, that the bones dug out of the earth, of particular shapes, are not really the bones of animals, but are crystallizations of lime, or some of its preparations, which were in some measure accidentally formed. This is rendered still more probable from the crystallizations frequently found in caves, having very striking resemblances to several of the preparations of art. It must appear very evident that the particles of matter coming together in the earth would there exercise their affinities peculiar to the state in which they were placed; and we know that this state may be changed ten thousand ways by the electric fluid as it passes through; and, in fine, by any substance. At least, this supposition appears less objectionable than those that the earth was once inhabited by an uncommon race of animals; that all these animals died, and that the earth burst open, and received the bones; or, that the sea inundated the land, and deposited the earth on those bones. All this, however, is only conjecture.

Nearly allied to the bones of animals are the *shells*, or hard coverings of many of them; such as those of fish, egg shells, &c. Shells, like bones, consist of lime, united to carbonic acid, whereas in bones it is united to phosphoric acid. The characteristic difference then between shells and bones, consists in this, that the chief ingredient of shells is chalk, or carbonate of lime; and the chief ingredient of bones is phosphate of lime. These shells may be decomposed by means of an intense heat, and converted nearly in the state of pure lime, as we daily see practised with oyster shells.

The compositions of the *crusts* of animals as they are called, is nearly the same as that of the shells: in some instances, however, they contain more of the phosphate of lime. All the inflexible, or hard parts of animals, may with propriety be considered as formed chiefly of either the carbonate or phosphate of lime; and they may all be decomposed nearly by the same means. Some of them are used as medicines, as common chalk.

HORNS AND SCALES.

THESE hard parts of animals are distinguished from the above, by a considerable degree of elasticity; by being softened by heat, and by containing but a small portion of lime. This set includes the substances known under the names of *horn*, *nails* and *scales*.

1. *Horns*, are bodies universally known to grow from the foreheads of oxen, sheep and various other animals. They are not very hard, as they may easily be cut with a knife, or rasped with a file; but they are too tough to be pounded in a mortar. When in thin plates, they have a degree of transparency, and in this state have been substitued for glass in windows. When sufficiently heated, they become very soft and yielding, so that their shape may be altered considerably, as is well known: this is facilitated when dipped in hot water; by this means combs are made from cows' horns in many country places. When strongly heated in Papin's digester, it is said they are converted into a gelatinous mass.

The quantity of earthy matter which they contain, is very inconsiderable. They consist chiefly of a membranous substance, which possesses the properties of coagulated albumen, and probably they contain a little gelatine. Hence we see the reason why ammonia or the volatile alkali is obtained, when these substances are submitted to strong distillation.

However, the horns of the hart and buck form exceptions to the above statement. They are found to differ in their composition from bone, only in containing a larger quantity of cartilage.

2. The *nails*, which cover the extremeties of the fingers, are attached to the skin, and come off along with it. They are composed of a membranous substance, which possesses the properties of coagulated albumen. Water softens, but does not dissolve them. They are readily dissolved and decomposed by concentrated acids and alkalies: and they agree very much in their composition with horns. Of this kind, are the talons and claws of inferior animals, and likewise their hoofs, which do not differ from horn.

The substance called *tortoise shell* is very different from shells in its composition, and approaches much nearer to the nature of *nail*. When long kept in the nitric acid, it softens and appears to be composed of membranes laid over each other, and possessing the properties of coagulated albumen.

3. The *scales* of animals are of two kinds: some of those of serpents, and other amphibious animals have a striking resemblance to horn; and also the horn-like substances which cover certain insects. The other kind, called the scales of fish, are found different in their composition. They contain a considerable quantity of the phosphate of lime.

OF THE MUSCLES OF ANIMALS.

THE muscular parts of animals, are known in common language by the term *flesh*. They constitute a considerable portion of the food of men. Flesh is composed of a great number of fibres or threads, commonly of a reddish or white color, as is well known. It is scarcely possible to separate it from all the other substances with which it is mixed. A quantity of fat adheres to it closely; blood pervades the whole of it, and every fibre is enveloped in a particular thin membrane, called by anatomists *cellular membrane*. Of course, the decomposition of the flesh or muscle connot be supposed to exhibit an accurate view of the composition of pure muscular fibre.

When a muscle is cut in small pieces, and well washed in cold water, it is converted into a white fibrous substance, which retains the form of the original body. This water when evaporated is found to contain some alumine, and a particular substance called *extractive* matter. If the muscle after this be boiled for a sufficient time in hot water, an additional portion of the same substance is separated from it, with a quantity of fat and albumen. The muscle thus treated with water, is left in the state of grey fibres, insoluble in water, and brittle when dry. This substance possesses all the properties of fibrina; and the water is found to contain a number of salts. According to Thouvenel, and Fourcroy, the muscles contain the following substances: 1. Fibrina. 2. Albumen. 3. Phosphate of soda. 4. Gelatine. 5. Extractive matter. 6. Phosphate of ammonia. 7. Phosphate of lime. 8. Carbonate of lime.

The two first of these substances, it is known, are composed of great quantities of nitrogen. Hence, when nitric acid is poured on flesh, great quantities of nitrogen air are extricated.

The muscles of different animals differ exceedingly from each other in their appearance and properties, at least as articles of food, but little is known concerning their chemical differences.

When meat is boiled it is obvious that the gelatine, the extractive, and a portion of the salts, will be separated, while the coagulated albumen and fibrina will remain in a solid state. Hence the flavor and nourishing nature of soups. When meat is roasted, and particularly when its surface is suddenly exposed to a strong heat, so as to coagulate the albumen and prevent the exit of the juices, then its taste and odour is much exercised. The heat acts as before observed, only by creating *states* in which the affinities of the particles of the meat are differently exercised, so that palatable combinations take place.

Meat, it is well known has a remarkable tendency to undergo changes within itself, called *putrefaction*. Many attempts have been made to retard this progress; and several succeed in preventing it at least for a considerable time.

The freezing temperature is a complete preservative from putrefaction, as long as the animal bodies are exposed to it. Hence, the common practice of keeping meat in snow in the frozen climates of the north; and, also, of packing fish up in it, and sending them to market.

It is well known that common salt prevents putrefaction in large quantities; but it is found to quicken it when the quantity is but small. Several other salts, especially nitre, possess the same property. The acids, particularly the carbonic acid in the state of air or mixed with water, syrup, ardent spirit, and many aromatic substances, such as camphor, resins, volatile oils, bitumens, &c. also act with considerable efficacy in preventing flesh from putrefying. Hence these last substances are used in *embalming* the dead bodies of some persons.

Besides these methods of preventing putrefaction, the bodies are frequently preserved by placing them in situations where their fluid parts are carried off. The Indians particularly, preserve their flesh by suspending it in chimney corners, where the hot smoke conducts off the moisture. In some instances, the bodies of men have been buried in dry earth, which rapidly absorbs the moisture of the bodies, and in consequence of this, the carcases become dry, and are transformed into what are called *mummies*.

The theory to explain these facts is not quite satisfactory. However, as observed by Dr. Thompson, it is very probable that these substances solely prevent putrefaction, by depriving animal parts of their water. It is well known that for putrefaction to take place the presence of water is necessary. Now when salt, and such bodies are rubbed on meat, they unite with the water and form with it a new compound, which differs very much from common water. Of course then the bodies cannot putrefy until they absorb water from the air. There is no doubt but that the bodies preserved by drying them, owe their preservation to being deprived of that water necessary for putrefaction to take place.

OF THE SKIN.

THE skin is that strong thick covering which surrounds the bodies of animals. It is well known, that the skins of different animals differ very considerably in several respects, and that even the skin of the same animal is not equal in its composition. What is commonly called skin, consists of two very different substances joined together; yet they may be separated very readily from each other, when kept in putrefying water for several days. The exterior or outer part may, by maceration in water, be obtained from common skins; it is called by anatomists *cuticle*, or *epidermis;* and it is that part which rises up when blisters are formed on the body. It is remarkably elastic, and is not possessed of sensibility. But little is known concerning its nature of any consequence. When the nitric acid is applied to it, and particularly if a little ammonia be afterwards applied, it is tinged of a deep orange color, just as coagulated albumen is. This has led to the conclusion, that it is albumen a little modified.

The interior part of the skin differs very much from the above. It is called *cutis*. It appears composed of fibres, interwoven like the texture of a hat. When distilled, it yields the same products as fibrina. When boiled in water for a long while, it is dissolved, and is converted into gelatine or glue, of which we have treated. Hence it appears, that the cutis is nothing more than a peculiar modification of gelatine, which resists the action of water in consequence of the compactness of its texture. It is this part of the skin which unites to *tannin* and forms leather. Of the method of tanning leather, we treated when considering tannin.

OF MEMBRANES, TENDONS, LIGAMENTS AND GLANDS.

THESE substances have not been much examined by chemists. The following is stated concerning them.

1. *Membranes.* These are thin semi-transparent bodies, which cover certain parts of the body, especially in the abdomen or belly. The thin coat usually pulled from hog's lard, is one of this kind. Membranes are soft and pliable. When dissolved in hot water, they are converted into gelatine; and when kept in an infusion of tannin they are converted into leather. Hence they resemble skins very much.

2. *Tendons*. These are strong, pearl colored, brilliant bodies, which terminate the muscles and attach them to the bones: they are commonly called *sinews*. When boiled they assume the form of a gelatinous substance, of a pleasant taste, as observed in parts of boiled meat. Its composition, therefore, resembles that of skins.

3. *Ligaments*. These are strong bands which bind the bones together at the different joints. They resist the action of water, and possess a great deal of elasticity and strength. They contain some gelatine, but differ very much from skins.

4. *Glands*. These are a set of bodies, employed to form the different liquids or *secretions* found in animals; as the liver, kidneys, glands of the brain, &c. It is very probable that they differ but little in their composition from muscular fibres, as they are formed of fibres.

OF THE BRAIN AND NERVES.

THE brain and nerves are the instruments of sensation and life: they strongly resemble each other. The brain has a soft feel, not unlike that of soap; its texture appears to be very close; its specific gravity is greater than that of water. When distilled it yields much volatile alkali, as also when pure potash is added to it. It appears to contain albumen; but, upon the whole, differs materially in its composition from other parts of the body.

OF HAIR AND FEATHERS.

THESE substances cover different parts of animals, and appear designed by nature to defend them from the cold. Their pliability and softness, and their resisting the passage of heat, adapts them for this purpose.

Hair is usually distinguished into various kinds, according to its size and appearance. The stiffest is called *bristle*; when fine it is called *wool*; and when very fine it is called *down*. In their composition, however, they resemble each other.

On examination with a magnifying glass, hair appears as a tube with a cover. Its surface is not smooth, as must be evident from the roughness of its feel; and the tendency it has to entangle itself, has given rise to the process of *felting* and *fulling*. It contains gelatine, to which it owes its suppleness and toughness. This substance may be separated by boiling; and then the hair becomes very brittle.

The rapidity with which hair burns, and its fusion at the time, is known to every one. When subjected to destructive distillation, Berthollet states that the following products were obtained from 1152 parts of it:

90 carbonate of ammonia,
179 water smelling of burnt hair,
288 oil of a brown color,
271 airs,
324 coal attracted by the magnet.

1152.

The alkalies dissolve hair at a boiling heat, and form with it an animal soap. When muriatic acid is poured on a solution of it in potash, sulphurated hidrogen air is extricated; hence it contains sulphur. The nitric acid tinges it yellow, and the nitrate of silver washes it black.

Feathers seem to possess very nearly the same properties with hair. The *quill* is composed chiefly of coagulated albumen. It is customary to boil them in oils abroad before they are made into pens for writing.

OF SILK.

THIS is the last of the hard parts of animals we have to consider. It is the production of different species of caterpillars. It is found inclosed in two small bags, from which it is protruded in fine threads to serve the insect for a covering during its young state. The webs of spiders are of the same nature with silk, though their threads are finer and weaker. Naturalists have ascertained, that the larger kinds of spiders, spin webs sufficiently strong to be manufactured; and that the produce was equal in beauty and strength to the silk of the silk worm. In consequence of this attempts were made to establish a manufactory of this new kind of silk; but it was found that the spiders would not work in concert. They attacked and devoured each other without mercy, till the whole colony was destroyed to an individual.

The silk worm is a native of China, and feeds on the leaves of the white mulberry. It spins the silk in the state of fine threads, varying in color from white to reddish. It is very elastic, and has considerable strength, if its diameter be taken into consideration. It is covered with a varnish, to which it owes its elasticity. This varnish is soluble in boiling water, and when the water is evaporated it is obtained of a black color, brittle, and of a shining fracture. Its weight is nearly one third of the raw silk, from which it was extracted. It may be separated from silk by soap as well as water.

Besides the varnish, silk contains a substance like *resin*, to which it owes its yellow color. It is soluble in ardent spirit, and in a mixture of ardent spirit and muriatic acid: this mixture leaves it of a fine white color. And in consequence of this it may very advantageously be used for bleaching the common yellow silks. For this purpose it is only necessary to mix together four parts of ardent spirit, and one of muriatic acid. The silks are to be kept two or three hours in warm water, and should then be introduced in the mixture, and kept there for ten or fifteen hours. It should then be washed in water, and again kept in another mixture about the same time. If the mixture be warm the operation may be shorter. The silk should then be kept in spirit alone a few hours, and then must be repeatedly washed in common water.

The properties of pure silk have been but imperfectly examined. It is not acted on by water or spirit; it is tasteless, and burns badly, but the fire rapidly turns it of a black color. When distilled it yields large quantities of ammonia. It is not very susceptible of putrefaction unless when in a damp place, and then it readily *rots*, to use a common expression.

DISCOURSE XIV.

HAVING given the preceding account of the solids of animals, I proceed to consider the remaining parts, which come under the head of *soft parts*. The most important of these are *blood*, *milk*, *bile*, *gastric juice*, *urine*, *poisonous secretions*, *saliva*, and all the other fluids formed from the blood which are called *secretions*.

OF BLOOD.

THIS is the well known fluid which circulates through the arteries and veins of animals, and of which all animal parts are formed. It is of a red color, has a considerable degree of consistency, and an oily feel. Its taste is slightly saline, and it has a peculiar smell.

When blood, after being drawn from an animal, is allowed to remain some time at rest, it very soon undergoes a change; one part of it separates from the rest, and forms a clot, while the rest is more fluid, and has the appearance of water. This process is called *coagulation;* the clot is called the *coagulum*, and the remaining part is termed the *serum*. This separation is similar to the conversion of milk to clabber.

The proportion between the clot and the serum varies very much in different animals, and indeed in the same animal at different times. The most common proportion is that of one part of the coagulum to three parts of serum. This coagulation of blood takes place in open vessels, and in the open air, whether the temperature be increased or diminished, or the blood diluted or not with water. It has been attributed by Mr. John Hunter and his followers to a vital principle, but I do not see why it should not be considered as a *law* of the blood, by which its particles of a certain kind come together.

The fluid which remains, called the *serum*, is of a light greenish yellow color. It has the taste and smell and feel of blood; but it is not so thick. It converts the syrup of violets green, and therefore contains an alkali; which is found to be soda. When heated to the temperature of 165° it coagulates, like the white of an egg, into a hard mass, from which however, some fluid, chiefly water, may be obtained. This mass is found to be possessed of all the properties of coagulated albumen.

Besides albumen, the serum is found to contain gelatine, which will appear by boiling it in six times its weight of water, and then gently evaporating the fluid.

If this serum be heated in a silver spoon, the surface of the silver will become black, in consequence of its uniting to sulphur, obtained from its contents. Hence serum contains sulphur.

If the serum of the blood be mixed with water and coagulated by heat; and if the fluid parts remaining be evaporated considerably, on laying it aside to cool, a number of crystals will appear, which are found to consist of the carbonate, phosphate, and muriate of soda with the phosphate of lime. And thus it appears that the serum of the blood contains albumen, gelatine, sulphur, soda and muriate, and phosphate of soda, and phosphate of lime.

The *coagulum*, or clot, is of a red color, and possesses considerable consistence. If this be washed very carefully in water for a long time, it loses its coloring matter, and appears of a white color, possesses elasticity, and in fact is *fibrina*, the substance we have described.

If the water in which the blood was washed be preserved, evaporated and examined, it will be found to contain an oxid of iron on which its color much depends, and also a small quantity of albumen and soda. The oxid of iron, it is stated, exists in combination with the phosphorous acid forming a *phosphite of iron*, which is of a red color, and soluble in serum.

When new drawn blood is stirred briskly round with the hand or a stick, the fibrina or coagulum collects on the stick, and may be separated from the rest of the blood.--- The red part in this case remains behind in the serum. It is in this manner, that blood is prepared for the different purposes to which it is applied, as clarifying sugar, making puddings, &c. When thus treated, the blood does not coagulate on resting.

Blood then appears to be a very compound fluid, is composed of no less than ten different substances; to wit.--- 1, Water; 2, fibrina; 3, albumen; 4, gelatine; 5, sulphur; 6, soda; 7, phosphate of iron; 8, muriate of soda; 9, phosphate of soda, and 10, phosphate of lime.

The blood, as before observed, is subject to very great changes. In the arteries it is of a bright color, which it received from its union with oxigen in the lungs. In the veins it appears much darker; and sometimes almost black, as it runs from their orifices. On exposure, however, to air, it loses this dark color, in consequence of absorbing oxigen; and appears as bright as that obtained from the arteries.

It has long been known, that blood drawn from a person laboring under inflammation, is soon covered with a white crust, which physicians call the *buffy coat*. This is found to be nothing more than the fibrina of the blood, which before coagulation, allowed the coloring matter to subside.

During the disease called the *diabetes*, in which the urine is excessive in quantity, and has a sweet taste, the serum of the blood is stated by Dr. Rollo to assume the appearance of whey; and loses its salt taste. However, in some very remarkable diseases, such as putrid fever and scurvy, it has been found that the blood undergoes no change, which adds to the many proofs, that it is wrong to attribute diseases to the state of the blood.

OF MILK.

MILK is a fluid formed in females, for the nourishment of their offspring. In different animals, it is distinguished by different peculiarities. But the animal whose milk is most used by man, is the *cow*; with its properties we are best acquainted, and therefore we will consider this first.

The milk of the cow is known to be a white fluid, to possess a slight peculiar smell, and a pleasant sweetish taste. When just drawn from the cow, it has a taste very different from that which it acquires after standing for some time. It boils at the temperature of boiling water; it is specifically heavier than water, and lighter than blood; it has an oily feel.

If fresh milk be left to rest for some time, in a cool situation it undergoes a change. In the first place, there arises on the surface a thick substance called *cream*. When this is removed the remainder is termed *skimmed milk*, which is of a blueish cast, and is more fluid than before. Some time afterwards, particularly if in a warm temperature and exposed to fresh air, it separates into a solid, called clabber, or *curd*, which when removed, leaves the fluid called *whey*.

This separation of milk into curd and whey, may be effected by the addition of other substances, such as the strong acids, several vegetable snbstances, and particularly by the stomach of calves, called the *rennet*, which is used in the preparation of cheese.

Cream. This part of the milk, which is the lightest, and consequently rises to the surface, contains an oil, which on being exposed to the air, and *churned* is converted into an hard substance, *butter*, which we will presently consider.

Curd. This coagulated part of milk, when fresh, is a white substance, somewhat elastic; but is of more or less consistence according to the quantity of whey it contains. It is insoluble in water, becomes hard in hot water, and is readily dissolved by the acids. When salted and compressed, it forms the well known article, *cheese*, to be considered hereafter. In some of its properties curd resembles albumen.

Whey. This fluid, which remains after the separation of the cream and curd, is of a yellowish color, and has a sweet agreeable taste. It is always turbid, and is best clarified by the white of eggs. It is called *sweet whey*. It is sometimes used in medicine, and is prepared by adding half a dram of powdered cream of tartar, or a few tea spoons full of lemon juice to a pint of milk, brought to the boiling point, and kept so till the coagulation of the curd is complete. It is then clarified by white of eggs, and deprived of its sourness by a little chalk. An agreeable drink is sometimes made by adding five or six ounces of good sour white wine to a pint of boiling milk, and then straining the whole.

Whey is used in the bleaching of linen. The linen is left eight or fifteen days in large vessels containing this fluid, and when taken out it is perfectly bleached. In this case it is the acid of the whey which destroys the coloring matter of the linen.

If the whey of milk be evaporated, there will be obtained crystals of sugar, which are called the sugar of milk. This gives it the power of undergoing the vinous fermentation, and forming an intoxicating liquor of course. If on the contrary, milk has become sour before coagulation, the liquor that remains is called *sour whey*. Sweet whey, by rest, will undergo the acetous fermentation and become sour: particularly if a small quantity of ardent spirit be added. This acidity is attributed to a particular acid, called the *lactic acid*. In some instances the whey is found to contain an oil, when obtained from cheese just made. Besides sugar and sometimes an acid, whey contains other substances, particularly some of the preparations of lime, as the phosphate, sulphate, and muriate of lime, and sometimes common salt. These may be procured by evaporating the whey. The proportion of water in whey is very considerable; and, in fact, it is stated by Dr. Young, that upwards of seven eights of common milk is nothing more than pure water.

Milk therefore contains, according to the above statement, an oil;--curd, whey, or water holding in solution several neutral salts.

It is with the utmost difficulty that new milk will putrefy. Hence it is frequently used to impart an agreeable taste to wines. However, it is very susceptible of the acetous fermentation; this, in cold weather, requires several days, but in summer it takes place in a few hours. Sometimes it suddenly becomes sour in consequence of changes in the atmosphere, as in stormy times. But this may in a great measure be prevented by previously boiling the milk. It is stated, that if to a quart bottle of milk one or two table spoons of ardent spirit be added, and the bottle be corked tight, but opened occasionally to let out the airs that are formed, then, in the course of two or three weeks, it will be converted into a most excellent vinegar.

If fresh milk be put into a moderately warm place, and be often stirred to prevent the separation of its parts, it undergoes the vinous fermentation. This process is quickened by the addition of a fermenting body, and on distillation a strong spirit may be obtained. The Tartars, and some Russians, are in the habit of drinking a liquor prepared from the milk of their mares, and sometimes from that of their cows. It is stated, that for this purpose, the milk pure and fresh, should be put in a vessel with a small neck, to which some fermenting fluid is added, and then it should be two or three times a day agitated for the extrication of the airs, during four or five weeks. On keeping it afterwards in vessels tightly stopped for two or three weeks its quality is much improved, and on distillation it will yield ardent spirit. Human milk, we are informed, will yield the most of this spirit.

Milk, when procured from cows directly after calving, is called *beastings*. It is of a yellow color, sometimes mixed with streaks of blood; it is thick and clammy, but its taste is like other milk. It is more difficult to coagulate it than other milk. After several days, the milk becomes of its usual appearance; however, the quantity of *curd* it yields generally increases with the time after delivery. The quantity of milk given by cows is always lessened when the diet of the cow is changed, and the original quantity is not given, until the animal becomes accustomed to the new food. The quantity of milk is also increased when the animal is accustomed to fluid food; but its quality is rather lessened. The peculiar properties of the food also have great influence on the milk. Every one knows that onions, garlic, clover, &c. give the milk particular disagreeable flavors, while the nutritious vegetables, as corn, and other seed, as certainly render it more agreeable. Hence, milk in the autumn is more agreeable and richer than in the spring. The richness of milk is usually judged of by the quantity of cream it yields; and the cream which first rises contains more butter than that which follows. Dr. Anderson states, that the quantity of cream collected from the milk of the cow, is different according to the time of its being drawn, and that the small quantity of milk, which comes the last, contains about sixteen times more cream than the same quantity drawn first at the same milking. The cream obtained from the last milk is also much richer, and of a deep orange color, while that of the other is white. "From experiments it appears," says Dr. Anderson, "that a person who, by bad milking of his cow loses but half a pint of his milk, loses in fact about as much cream as would be afforded by six or eight pints at the beginning; and loses besides that part of the cream which alone can give richness and high flavor to butter."

With respect to the separation of cream from the milk, it appears to take place with the greatest regularity, in a temperature of from 50° to 55°, and when the heat exceeds 65°, the milk soon coagulates, and yields but little cream. The quantity of cream is also lessened if the milk be agitated; but it is increased, if allowed to rest in large open vessels with a wide surface exposed. It is supposed, that in this case the cream acquires consistence from the absorption of oxigen from the air.

Butter. This is obtained as every one knows by churning the cream or milk of the cow. Butter is in general of a yellow color, but sometimes it is as white as fat, and of an inferior quality. The color, however, depends very much on the state or constitution of the animal; yet the food has no doubt some influence. The contact of the air has likewise an effect in coloring it, for in some instances, that which is quite white, acquires a yellow color a certain time after its preparation, and on being cut, appears less yellow internally.

But the quantity and agreeable flavor of butter is of much more consequence than its color. In order to extract in largest quantities, some management is necessary.

According to Mr. Robinson, butter from cream is much richer than that from milk, but it is less in quantity, and does not keep so long sweet. Doctor Anderson states that if the cream be got from milk, exposed to too low a temperature, the butter when extracted will be pale; very small in quantity; of little taste; very hard, and of no value. Butter likewise, when extracted from new cream, tastes more agreeable than when extracted from old: for, to make butter of the best quality, it will not only be necessary to separate the first drawn milk from the rest, but likewise to take only the cream that is separated from the best milk, as it is only the first rising cream, that is of the best quality. Thus the richness of the highland butter is attributed by Dr. Anderson to the practice of giving the first drawn milk to the calves, and keeping the rest for the dairy; and the quality and richness of the butter will be improved in proportion to the smallness of the quantity of the last drawn milk. Another circumstance, in the separation of butter from cream, is, that it does not take place till after the last has become sour; if, therefore, it be agitated before that acidity has begun no butter can be obtained, and the agitation must be continued until that sourness be produced, after which the butter begins to form. Hence, the cream ought to remain in the vessel appropriated for keeping it, until it has acquired that proper degree of acidity by which butter is easily extracted by a moderate degree of agitation; and only by this process can very fine butter be obtained. In summer, while the temperature is warm, if the agitation be continued until the acidity is produced, the process of churning will be long and tedious, and the butter of a soft consistence; and in winter the disadvantages are greater. Cream, therefore, which has been kept three or four days in summer, is in an excellent condition for producing butter. And Dr. Anderson states that from three to seven days, in general, will be found the most proper time for keeping cream before it is churned. Mr. Fourcroy states that a quantity of oxigen is in this time absorbed by the cream, which is the cause of its superiority over that which is fresh; and it is also very probable that oxigen is absorbed during the churning. It is certain that a quantity of carbonic acid air is extricated during this process.

Doctor Anderson states that in the western part of England the best butter is made as follows: the milk is first deposited in earthen pans, where it remains twelve hours in summer and twenty-four in winter; they are then removed to stoves, heated for that purpose with hot embers; here they remain till bubbles arise, and the cream changes its color: this is called *scalded cream*. It is then removed with care to the dairy where it remains twelve hours longer, when it is skimmed and the cream is churned. This, when deprived of its salt by washing, is said to be equal to the best fresh butter.

For those who wish to make most butter from their milk, it would not be adviseable to separate their cream from their milk. From experiments I have repeatedly seen made on my father's farm, it is unquestionably most advantageous to allow the milk to be converted into *clabber*, or to be coagulated, and then to churn it with the cream. The quantity of butter yielded by so doing, is invariably greater, and the family think of better quality, than that yielded by other means; and the buttermilk is also found uncommonly good.

Butter, when melted, has its properties materially changed: Its color, taste and texture become altered. It is partly transparent, and appears in the form of grains; its taste is insipid, and similar to that of fat. These changes which butter undergoes by melting, are caused by the separation of some mucilage and its curd, to which the butter owes its agreeable qualities.

Common butter, it is well known, is very apt to lose its delicate flavor, and acquire a strong disagreeable sharp taste, commonly called *rancidity*. It appears to be more susceptible of this change, than other oily matters. This rancidity arises, it appears, from the same cause as that of other oils; viz. from the absorption of oxigen from the air by a mucilage. And the way to lessen its tendency to become rancid, is to lessen the quantity of this mucilage, and prevent the contact of oxigen. The mucilage is deposited by melting the butter; but this method is not practised, in consequence of its depriving the butter of its agreeable taste. Much of the mucilage, however, may be extracted by repeatedly washing the butter, particularly in warm water; and the butter so served, is found to remain under common circumstances a great while longer without becoming rancid, than common butter. The tendency to rancidity is also lessened, by keeping the butter in a cold place.

In order to preserve butter more effectually from becoming rancid than common salt can, the following method has been very strongly recommended. Take one part of sugar, one of salt petre, and two of the best common salt, and rub them up together very finely. One ounce of this is to be mixed with a pound of butter, as soon as it is freed from the buttermilk by washing. It is then to be put in a close and dry vessel, from which the air is to be excluded; and it will remain pure for many years.

Buttermilk. This is almost uniformly found to retain a portion of butter, diffused in small lumps. In most of its properties, it bears a very striking resemblance to *skimmed milk.* It is however of a white color; is more palatable, and is consequently very generally used, particularly by the servants of the southern states, as an article of diet.

Cheese. This is an article known many hundred years ago : as before observed, it is prepared from the curd of milk. It is valuable in proportion to the quantity of cream it contains. It is well known to cheese makers, that the excellence of cheese depends in a great measure on the manner of separating the whey from the curd. If the milk be much heated, the coagulum broken in pieces, and the whey forcibly pressed out, the cheese is scarce good for any thing; but the whey is delicious, especially that last squeezed out, and butter may be obtained from it in considerable quantity, which shows that the cream was separated with the whey. Whereas, if the milk to be made into cheese be not much heated (a temperature of 100° is sufficient); if the coagulum be allowed to remain unbroken and the whey be separated by very slow and gentle pressure, the cheese is excellent, but the whey is nearly colorless, and contains no cream. Cheese so made melts at a moderate heat in consequence of its oil, which gives it flavor and smell. But bad cheese when heated, dries, curls and exhibits the appearance of burning horn.

Cow's milk is not the only milk employed in making cheese. The milk of the goat is very frequently used for the purpose; as the cheese made from it is very rich marrowy, melting, and of an agreeable taste. The milk of sheep is also employed in some parts for making cheese. The famous *Roquefort cheese* is made by a mixture of goats and sheep's milk. It must readily appear that a great variety of flavored cheeses may be made, by mixing in various proportions, the milk and cream of different animals; and then a good deal depends on the particular manner of making and preserving it. It is always adviseable to keep cheese in cold places and properly salted.

The article used for the coagulation of milk is called *rennet*, which is the fourth stomach of calves. This is usually dried and preserved for use. It operates by virtue of a secretion it contains, called the *gastric juice*, which is formed in the stomach of all animals. Hence, we find the milk vomited by children, is usually coagulated in consequence of the gastric juice of their stomachs. When the rennet is added to milk, or cream heated to 100° as above, it requires from one fourth to half an hour for its gastric juice to be dissolved to coagulate milk.

It may not be amiss to add the following receipt for making *Stilton cheese*, which is taken from the newspapers.

"Take the night's cream, and put it to the morning's new milk, with the rennet; when the curd is formed, it is not to be broken, as is done with other cheese, but take it out with a soil dish altogether, and place it in a sieve to drain gradually, and as it drains, keep gradually pressing it, till it becomes firm and dry; then place it in a wooden hoop; afterwards it is to be kept dry on boards, turned frequently with cloth binders round it, which are to be lightened as occasion requires. It is customary after these cheeses become sufficiently firm, to rub them every day, particularly in moist weather with a dry cloth."

THE milk of all other animals consist nearly of the same ingredients as cows' milk; but there is a great difference in the proportions of these ingredients, as will appear from the following:

Woman's milk has a much sweeter taste than cow's milk. When allowed to remain at rest for a sufficient time, a cream gathers on its surface. This cream is more abundant than in cow's milk, and its color is usually much whiter. After it is separated, the milk is exceedingly thin, and has more the appearance of whey, with a blueish white color, than of skimmed milk. The methods by which cow's milk is coagulated, do not succeed in coagulating women's milk. However, their milk contains curd, for if it be boiled the curd rises on the surface. Its not coagulating, is attributed to the great quantity of water it contains.

Though the cream of this milk be churned ever so long no butter can be obtained from it; but if after being agitated for some hours, it be allowed to remain at rest for a day or two, it separates into two parts; a fluid which occupies the lower part of the vessel, which is colorless like water; and a thick white oily fluid, which swims on the surface. The lower fluid contains sugar of milk, and some curd, the upper one does not differ from cream, except in consistence. The oily part of this cream then, cannot be separated from its curd: and this cream contains a greater portion of curd than the cream of cow's milk.

When this milk, after the curd is separated from it, is slowly evaporated, it yields crystals of the sugar of milk and common salt. The quantity is rather greater than that afforded by cow's milk.

Thus it appears that woman's milk differs from that of cow's in three particulars.

1. It contains a much smaller quantity of curd.

2. Its oil is so intimately combined with its curd, that it does not yield butter.

3. It contains rather more sugar of milk.

It should be observed that the quantity of curd in woman's milk increases in proportion to the time after delivery; and nearly the same has been observed with respect to cow's milk.

Ass's milk, has a very strong resemblance to human milk; it has nearly the same color, smell and consistence. When left at rest for a sufficient time, a cream forms upon its surface, but not in such abundance as upon woman's milk. This cream by very long agitation yields a butter which is always soft, white, and tasteless; and what is singular, very readily mixes again with the buttermilk; but it may be again separated by agitation, if the vessel containing it be kept cold. This milk when skimmed, is thin, and has an agreeable sweetish taste. Ardent spirit and acids separate from it a little curd, the consistence of which is considerable. The serum yields a sugar of milk, and muriate of lime by evaporation.

Ass's milk, therefore, differs from cow's milk in three particulars :

1. Its cream is less abundant and more insipid.

2. It contains less curd.

3. It contains more sugar of milk.

Goat's milk, if we except its consistence, which is greater, does not differ much from cow's milk. Like that milk, it throws up abundance of cream, from which butter is easily extracted. This milk, when skimmed, coagulates just as cow's, and yields a greater quantity of curd. Its whey contains sugar of milk, muriate of lime, and common salt.

Ewe's milk resembles very strikingly that of the cow. Its cream is rather more abundant, and yields a butter, which, however, never acquires the consistence of cow's milk. Its curd has a fatty appearance, and may be readily made to assume the consistence of the curd of cow's milk. It makes very valuable cheese.

Mare's milk, is thinner than that of the cow, but not so thin as woman's milk. Its cream cannot be converted into butter by agitation. The skimmed milk coagulates precisely as cow's milk, but the curd is not so abundant.--- The serum contains sugar of milk, sulphate of lime, and muriate of lime.

OF BILE.

BILE is a liquid which is formed in the liver, of a yellowish green color, an oily feel, bitter taste, and peculiar smell. In most animals, considerable quantities of it are usually found collected in the gall bladder, and it is commonly called *gall*.

When strongly agitated, bile lathers like soap and assumes a yellow color; but it will not unite with oils. However, it dissolves a portion of soap readily, and is often employed to free cloth from greasy spots. When four parts of vinegar and five of bile are mixed together, the mixture has a sweet taste and does not coagulate milk. The acid of milk has precisely the same effect as vinegar. If bile be heated, and slightly evaporated, it may be kept for many months without putrefying.

A great number of experiments have been made with bile; but they are not of much consequence. They were performed with a view to throw light on the treatment of the diseases which are called biliary. But they have not thrown any light whatever on the subject. They have established the fact,however,that it is a very compound fluid, and generally contains a portion of the following substances: 1 water, 2 resin, 3 albumen, 4 soda, 5 sulphurated hidrogen, 6 a sweet salt, 7 common salt, 8 phosphate of lime.

It is worthy of being recorded, that Mr. Fourcroy, a French chemist, has been able to procure bile from the blood of an ox. He did it simply by coagulating blood, by boiling it in distilled water; and then filtering it and evaporating the fluid. The fluid which is obtained is of a green color; and when evaporated to the consistence of honey, it was precisely like bile.

Most of the acids when added to bile, render it of a deep green color. It is to this cause, that the bile vomited up from the stomachs of patients, is so generally of a green color; the color being given by the acids found in the stomach.

The uses of bile are not exactly known. Many have supposed that it is an excretion designed merely to free the system from an injurious fluid: but with greater probability it is stated to serve as a stimulus to the intestines, to keep up their motion. Hence in doses of one or two ounces, it is generally given to excite purging. However, nothing is more certain, than that the common notions about bile's being the cause of fevers, are unfounded and absurd. In the first place, but a small quantity of it can remain at once in the stomach and bowels: and the large quantites which are evacuated when an emetic is taken, are brought out of the gall bladder at the time of vomiting, in consequence of the convulsive motion of the stomach. It is this motion of the stomach, which proves of service to patients laboring under supposed biliary fevers, and not the evacuation of a little bile.

OF THE GASTRIC JUICE.

THIS is a fluid found in the stomach of all animals ; it is secreted by small vessels which line the inner coat of the stomach. When food is taken into the stomach, this juice acts upon and dissolves it, and in consequence adapts it for entering into the general circulating mass. It is to be considered as a solvend for the food of animals.

The properties of the gastric juice are found very much to vary with the diet of animals. In all animals it dissolves the particular food to which the animal is accustomed; but it does not act on that to which the stomach is not habituated. In consequence of this, the gastric juice of an animal living on meat, will not dissolve a vegetable substance; nor will that of an animal living on vegetables act on meat. Hence the stomachs of eagles, or any other carnivorous animals, will not digest vegetables; nor will the stomachs of sheep, horses or any other herbivorous animals digest flesh. However, on accustoming the stomachs of these animals to any kind of food, in time, they will be brought to digest it completely; so that such is the nature of the stomach, that it varies its secretions, and secretes a proper menstruum for the food applied to it. Hence horses, cows, sheep, &c. may be made to live on flesh; and eagles, &c. to live on vegetables.

Although the gastric juice of animals varies with the diet of the animal, yet it is possessed of general properties, by which it may be distinguished. It resists putrefaction in a great degree. Hence, on introducing putrid flesh, &c. in the stomachs of animals, it is frequently rendered perfectly pure. It curdles or coagulates milk. Hence the reason that children frequently throw up curd after sucking their mother; hence the *rennet* or fourth stomach of calves is used to convert milk into clabber. The gastric juice or the rennet is dried, and then dissolves in the milk to coagulate it. Would it not be well, instead of preserving the stomach's of calves to make cheese, to procure the juice from the stomach's of animals, and evaporate it in the sun to dryness, and use it as occasion requires?

The gastric juice of animals, frequently contains an acid, which has been generally found to be the phosphoric acid. This acid, however, is not, as has been supposed, the cause of its coagulating milk. Some times the contents of the stomach undergo an acetous fermentation, and then different acids are produced. At other times, in cases of disorders of the stomach, the gastric liquor is found to be of an alkaline nature.

The importance of this fluid in animals must appear very considerable. Besides its use in the animals in which it is formed, it has been recommended as a medicine, when taken from their stomachs. To old ulcers, it has been applied with great success, and it has been successfully exhibited to patients laboring under debility and indigestion. On this subject, it may not be amiss to extract the following from my Thesis. "The difficulty of procuring the gastric juice, may prevent its introduction into general use; but if in a few cases it affords relief, it is entitled to a place in the Materia Medica. This objection, however, cannot be urged against our using it in a manner, and for a purpose I will now propose."

"It is well known that there are medicines (resins, for example) which are soluble in the gastric juice only when blended with gum or mucus. This appears the reason why aloes will act only in the rectum, where it can unite to the mucus of the gut. It must appear very evident, that most medicines do not act on the stomach before they are *dissolved* in its juice or menstruum: Nor can it be doubted, that the effects of medicine vary with their solvent or menstruum. Now as the gastric juice is liable to the greatest changes, we frequently see the same medicine producing different effects on different persons; and it must be also on this account, that the same medicine produces different effects at different times on the same person, and that in other instances, only particular forms of a medicine will produce an effect. Dr. Rush in speaking of clinical cases, observed that opium in substance, in a pill he had found to check vomiting, when no other of its preparations would. And in the case of my dear mother, lately affected with an incessant vomiting, I found that only a watery solution of opium would yield relief. Authors have observed in some instances, that very active medicines would prove either inert, or exert some uncommon power on the system. To prevent such occurrences, I imagine it is only necessary to mix the doses with a small quantity of the gastric juice of healthy carnivorous animals. This would be the more proper in dangerous cases, where at critical periods, a slight irregularity might prove destructive.--- This suggestion appears so plausible, that I cannot avoid wishing, that practitioners will at least ascertain if it deserve to be prosecuted."

OF URINE.

NO animal substance has attracted more attention than urine, both on account of its supposed connexion with diseases, and on account of the very singular products which have been obtained from it. When fresh, it differs considerably in its appearance, this depending on the state of the person, and the time at which it is voided. In general, healthy urine is a transparent liquid, of a light amber color, an aromatic odour, resembling that of violets, and a disagreeable bitter taste. When it cools, its strong odour leaves it, and it is succeeded by another, well known by the name of *urinous smell.* This smell is succeeded by that of another, resembling sour milk, which in its turn gives way to an alkalescent and fetid odour.

If urine be evaporated by a slow fire, to the consistence of a thick syrup, it assumes a deep brown color, and exhales a fetid ammoniacal odour. When allowed to cool, it concretes into a mass. If four times the weight of ardent spirit be poured on this mass, at intervals, and a slight heat be applied, the greatest part is dissolved. The spirit appears of a brown color; it should be poured off, and distilled in a retort till the mixture has boiled for some time, and acquired the consistence of syrup. By this time the whole of the spirit has passed off, and the matter on cooling concretes. This substance is called UREA, which composes nineteen twentieths of the urine, provided the watery part be excluded. To this substance, the taste and smell of urine are owing; and in fact most of the characteristics of urine depend on it.

The quantity of *urea* varies considerably in different urines. In the urine voided soon after eating and drinking, very little of it is found, and still less in that which is voided during fits of the hystericks.

A number of experiments have been made, to ascertain exactly the constituents of urine. It is too uninteresting and useless to detail those experiments; however, it may not be amiss to notice the different substances, which have been found in it. They are upwards of eighteen, to wit: water, phosphoric acid, phosphate of lime, phosphate of magnesia, carbonic acid, carbonate of lime, uric acid, rosaic acid, benzoic acid, gelatine, albumen, urea, phosphate of soda, phosphate of ammonia, muriate of ammonia, muriate of soda, and sulphur.

No doubt, most of these substances which have been found in urine, are formed during the decomposition of it by art. Occasionally other compounds are also found in it;

such as the urate of soda, sulphate of soda, muriate of potash, &c. No substance putrefies sooner, or exhales a more detestable odour during its decomposition, than this secretion; but there is a material difference in the time in which this takes place in different urines. In some putrefaction takes place almost as soon as it is voided; whereas several days pass off before it takes place in other urine. This difference is found to depend on the quantity of gelatine and albumen which urine contains. When there is very little of these substances present, urine remains a long time unchanged; on the contrary, the greater the quantity of gelatine and albumen, the sooner does putrefaction commence. The putrefaction of one's urine is, therefore, in some degree, the test of the health of the person who has voided it: for according to Fourcroy, an abundance of gelatine in urine, indicates some defect in the digestive power. The presence of the gelatine may be detected by the addition of a solution of tannin to the urine.

Human urine is remarkably subject to alterations by disease: and the changes to which it is liable have long attracted the attention of physicians, as in some measure, they serve to indicate the state of patients, and the progress of the disease under which they labor. The following are the most remarkable of these changes that have been observed:

1. In inflammatory diseases, the urine is of a red color, and is very acrid; it does not deposit any thing on standing.

2. During jaundice, the urine has an orange yellow color, and communicates the same tint to linen. Muriatic acid renders this urine a little green, and thus detects the presence of bile.

3. On the termination of inflammatory diseases, the urine becomes abundant, and deposits copiously a pink colored sediment.

4. During fits of the hystericks, the urine usually flows abundantly. It is limpid and colorless, containing much salt, but little urea and gelatine.

5. The urine of gouty people, contains much less of the phosphoric acid than healthy urine.

6. In general dropsy, the urine is loaded with albumen, and becomes milky,, or even coagulates when heated, or at least when acids are mixed with it. In dropsy from diseased liver, no albumen is present; the urine is scanty, high colored, and deposits the pink colored sediment.

7. In indigestion, the urine contains much gelatine, and yields a copious precipitate with tannin.

8. The urine of patients laboring under rickets is loaded with the phosphate of lime.

9. In the disease called diabetes, the urine is sweet tasted, and of course contains sugar. According to Cruickshank, the urine voided daily by a diabetic patient, contained 29 ounces of sugar.

But our knowledge concerning the diseases indicated by the appearance of urine, is very defective, and nothing is more certain, than that the number of p—s Doctors, who pretend to prescribe medicines from the appearance of the urine, are vile impostors, although some of them have accidentally acquired in different parts of the country considerable reputation.

THE URINE

Of the horse is found to differ somewhat from that of man. It has a peculiar odour after exercise, it is emitted, thick and milky; at other times, it is transparent, but becomes muddy soon after emission. When exposed to the air, its surface becomes covered with a crust of chalk. It gives a green color to syrup of violets, and has the consistence of mucilage. It does not contain much urea, or any phosphorus, according to the experiments of Fourcroy.

The urine of the cow resembles that of the horse; but nothing is known of it, or of any of the other urines which have been examined worth particular attention.

The urine of animals, from the salts it contains, must readily appear to be capable of acting as a manure. It is used in the preparation of some dyes; and sometimes for the purpose of preparing phosphorus.

OF POISONOUS SECRETIONS.

SERPENTS, bees, scorpions, spiders, and several other animals are furnished with juices of a poisonous nature, which when poured into fresh wounds, occasion the disease or death of the wounded animal. From the small quantities in which these have been procured, their chemical properties have been but imperfectly examined. The following is the chief of what has been advanced on the subject.---A more particular account will be found in a most valuable paper, published in vol. iii. of the American Translations, by the indefatigable Professor, Dr. Barton of Philadelphia.

The poison of the viper is a yellow liquid, which is found in two small vessels in the animals mouth. These communicate by a tube with the crooked fangs, which are hollow, and terminate in a small cavity. When the animal bites, the vessels are squeezed, and the poison is forced through the fangs into the wound, where it produces the fatal effects of the viper's bite. Hence, if the vessels be extracted, or the liquid prevented from flowing into the wound, the bite is harmless; and if applied to wounds of the body, made with sharp instruments, it operates as powerfully, as when introduced by the viper itself. When applied to the tongue, this poison occasions a sense of numbness. It has the appearance of oil before the microscope, but it readily unites with water. When exposed to the open air, the watery part gradually evaporates, and a substance remains resembling gum arabic; and it is very soluble in water, but not in alcohol. It is precipitated from its solution in water, by the addition of ardent spirit, in the form of a white powder. Neither acids or alkalies have much effect upon it.

For a long time it was thought that ammonia or the volatile alkali was an antidote to the bite of the viper. It was applied, in consequence of the supposition that the poison was an acid, and that the alkali would combine with it. Fontana, however, found that it did not destroy the poison when mixt with it. Notwithstanding this, Dr. Ramsay has recommended it as a certain cure for the bite of the rattle snake.

The venom of the bee and wasp, is also a liquid, contained in a small vessel forced through the hollow tube of the sting into the wound inflicted by it. It is stated to resemble that of the viper; but to be much longer in drying. The poison of the scorpion resembles that of the viper also; but its taste is hot and acrid as that of the venom of bees and wasps. No experiments have been made of the poison of spiders. But from the rapidity with which these animals destroy their prey, and one another, it must be very strong.

OF SALIVA.

THIS is the fluid secreted in the mouth, and commonly called *spittle*. It is nearly as limpid as water, but is much more thick or viscid. It has neither taste or smell. When agitated, it froths like other adhesive fluids, and in fact, it is usually frothy in consequence of its mixture with air.

Saliva does not mix with oil: If rubbed up in a mortar with water they combine together pretty well. It has a great affinity for oxigen, absorbs it readily from the air, and gives it out again to other bodies. Hence the reason why gold or silver, rubbed up in a mortar with saliva is oxided: and why the mixture of mercury with oils is expedited by spitting in the mixture, as is often done by those making mercurial ointment: It is probable that it is on this account, that spittle is an useful application to sores of the skin; and that dogs and other animals have constantly recourse to this remedy for their ulcers.

Saliva when boiled in water, gives up a small quantity of albumen. When evaporated, it yields small crystals of common salt; and upwards of eighty parts of it, are found to be common water. According to the most accurate statement, the following substances exist in saliva: 1 mucilage, 2 albumen, 3 common salt, 4 phosphate of soda, 5 phosphate of lime, 6 phosphate of ammonia.

But it cannot be doubted, that like the other animal fluids, saliva is liable to many changes from diseases and variations of habit.

The concretions which are sometimes formed in the mouth, and particularly the tartar or bony crust, which so often attaches itself to the teeth, are chiefly composed of the phosphate of lime.

Besides the secretions we have considered, several others have been examined by chemists; but as nothing worthy of particular attention has been noticed, it will be useless to dwell on them.

DISCOURSE XV.

THERE are but few subjects which have excited more attention than the means by which animal parts are formed.

The *nutrientia*, or substances which enter into the composition, or which nourish animals, are universally known to be chiefly derived from the vegetable and animal kingdoms. Excepting the air and water, no other substances afford a support. The greatest quantity of nourishment is unquestionably derived from a given bulk of animal matter, when circumstances are the same, as the experience of every attentive observer will shew. It will also appear, that of animal substances, fat, blood, milk, flesh and soft bones are most nutrious. Hence the great vigor of animals accustomed to eating such food.

Of the vegetable substances yielding a support, the most remarkable are the following:

Sugar. This is universally known not only to be a very palatable, but a very nourishing article of diet. The negroes of the West Indies, annually grow fat while pressing the cane, in consequence of eating it in considerable quantities at that time. A variety of vegetable sweet substances owe their very nutricious qualities in great measure to the sugar they contain. Hence it is a proper article for children, and is invariably found in the milk which they suck.

Fecula or *starch*. This is also very nutricious. As before remarked it exists in many grains and roots, and renders them nourishing; as instanced in wheat, rye, barley, potatoes, &c.

Gluten, commonly is found in combination with fecula, particularly in nutricious grains, and no doubt adds to their qualities.

Gum. This is unquestionably to be ranked among the very nourishing vegetable bodies. The lives of people have been saved by eating gum arabic, when no other substance could be had. And perhaps it would be advantageous to make a greater use of the gummy or mucilaginous seeds in our diet The quince, flax, and water mellon seeds, appear to be particularly well adapted for food.

Oil. This is not less remarkable than the other substances we have named for yielding nourishment to animals. The olive oil of commerce is generally used, and particularly by the Turks, as an article of diet.

Acids, obtained from the vegetable kingdom, are also nourishing, particularly when in combination with other bodies; as with sugar in conserves, &c. It is, however, not known what are precisely their nutricious qualities. When uncombined, as in vinegar and lemon juice, and long used, they have been known to produce considerable disease in the stomachs of persons.

Besides the above substances, it is probable that some others, particularly those formed of carbon, nitrogen, oxigen and hidrogen, yield a support at least to some animals. Perhaps, also, the bodies containing acrid substances, as pepper, mustard, &c. may contribute towards nourishing the human race, as well as other animals; such are, however, chiefly used as condiments. In general, however, the nourishing qualities of an article to be used as food, may be judged of correctly by ascertaining the quantity of the proximate principles of vegetables contained in it, which were first named.

But the nourishing qualities of substances are found to depend very much on the habits of the animal. Before the articles combine with the animal bodies, they must remain some time in the stomach, and there be dissolved in the gastric juice, as observed while considering this secretion. It must be remembered, that the power of the gastric juice to act on the bodies taken in the stomach, depends greatly on the food to which the animal is accustomed. Hence, flesh will not shortly be digested by those accustomed to live on vegetables. Hence, when the stomach is diseased we find that bodies remain in it a long time, in some instances, without undergoing any change. Hence, in judging of the wholesome qualities of food, we must learn first the habits of the person. Hence the error of those, who on eating food, and vomiting it unchanged a day after, on being taken sick attribute their sickness to the food, forgetting (as I have known a physician of some note to do) that it was owing to the previous disease of the stomach, that the article was not acted on by the juice of the stomach. Hence, those who change their diet should do it very cautiously and gradually, lest they disorder their stomachs.

The food, when dissolved in the gastric juice, passes down through the bowels, which are lined with innumerable and small vessels. These small vessels absorb the greater part of it. No sooner is it absorbed, than it is converted into a white milky looking substance called *chyle*. This chyle is then conveyed by a large vessel which empties into one of the veins containing blood: here it mixes with the blood, and with it,is conveyed to the lungs; in which place it is converted into blood of a very red color, and distinguished by the name of *arterial blood*. This arterial blood, in consequence of the action of the heart and arteries, (which depends on the contraction of fibres,) is conveyed all over the body; where in some parts, it is converted into fibres, or a part of the living animal body; in other parts, it is changed into the fluids called *secretions*, as milk, urine, perspiration, fat, &c. And the last part returns through very small tubes, which unite and form veins. This blood is then of a dark color, and is known by the term *venous blood*. The veins convey it to the lungs, where again it is converted into *arterial* blood, and is as above circulated through the body ; constantly diminishing in quantity, and constantly supplied again from the food that is taken.

The blood of the veins unquestionably is in the lungs converted into red arterial blood,in consequence of the influence of the air we breathe, and the oxigen of this air: for whenever this oxigen air is withheld, the blood is unchanged, and the animal soon loses its heat and expires. Besides this, however, in the lungs, the blood gives out carbonic acid and moisture. Hence it is always found, that the oxigen of air which is breathed, is diminishing in quantity. It seems then that the lungs of animals are chiefly useful in consequence of their being so made or constructed, that the venous blood in them attracts the oxigen from the air which is applied to them; and that this oxigen converts the blood into red arterial blood, which is alone capable of answering the purposes of the body. The oxigen, however, in uniting to the blood in the lungs does not lose all its latent heat; for when the blood is conveyed to other parts, as to the extremities, it there loses its capacity to retain its latent heat, which consequently escapes in the form of sensible heat, and so causes the *warmth* which distinguishes most animal parts. Hence the heat of animals is found proportionate to the quantity of air they breathe. Hence the necessity of fresh air for the preservation of animal life and animal heat; and also the necessity of having a fresh quantity proportionate to the nature of the animal. This will appear the more clearly from the facts, that birds breathe more than other animals in proportion to their bulk, and their heat is about 106°, but the heat of fish is never found near as considerable, nor their respiration.

The arterial blood being properly formed, a most important question arises, concerning the means by which it is converted into the parts of the body, and into the secretions. This has long occupied the attention of those studying the nature of the animal body. The more I have reflected on this subject, the more am I convinced that the common modes of accounting for such phenomena, are far from being perfect. In my Inaugural Essay, I advanced a new theory on the subject, on which the more I reflect, the more does it appear to me to be the true explanation. Of the correctness of this, I am further persuaded by the concurrence of some of the first characters in the country. But a few days have elapsed, since I was favored with a conversation on this subject, with the learned Dr. Hosack, an eminent practitioner of physic of

New-York, and Professor of Botany in Columbia College. This gentleman without any hesitation, assured me that he believed the doctrine to be correct. I mention this, with a view to induce others to examine it more attentively, that its merit or defects may be decidedly ascertained. It may not be amiss to extract the following from my essay, from which an idea of the theory may be formed.

"When we contemplate the animal machine, we are struck with the extreme vascularity of all its parts. This is so general and considerable, that the human body has been emphatically called a "collection of capillaries." In these capillary vessels or small tubes, the most important operations are performed; for it is in these, that the blood is so wonderfully modified, as to be adapted to all the exigencies of the system. The most general operation we notice, is the conversion of arterial into venous blood.--- No part is exempt from this remarkable process, whereby the properties of blood become so materially altered. While we keep in view the uniformity and the simplicity of the operations of nature, we will account for this phenomenon on common principles."

"It is an undoubted fact, that the form and properties of most substances are variable, and depend on the circumstances in which they are placed. By experience and observation, we learn what changes can be produced, and what is necessary to produce them. For example: of water, we find that in a low degree of heat, the particles cease to roll on each other, and become so arranged as to constitute ice. In a higher degree of heat, another substance, the egg, is deprived of its fluidity, while the solidity of a metal is lost in the same temperature."

"In accounting for such phenomena, we do not call in the agency of an intelligent *vis vitæ*, or uncommon principle; neither can they be referred to one of the agents separately. We are to infer that they arise in consequence of the natural tendencies or affinities of the substances, exercised in consequence of the circumstances created by lessening or augmenting the heat. Let us extend this plan of making inferences from facts to the human body."

"But a little experience is necessary to teach us that the arterial blood, like most substances, is susceptible of the greatest changes, and that these changes can be varied with the circumstances in which it is placed. For example, in the arteries we see it is of a vermillion color; but, as Sir Isaac Newton long since observed, in a particular position it is yellow. We see, also, that it loses its fluidity when allowed to rest, or placed in a temperature above 160°. When allowed to rest, the coagulating lymph of the blood unites, and becomes solid. This tendency of the lymph is also seen in the granulations of wounds, which being covered with it readily unite together. The coagulum formed by the union of the lymph, possesses some of the characteristics of life. These I presume are acquired in consequence of the union, and partial organization of the lymph, effected by the attraction of cohesion. Hence, such causes (as lightning) which prevent the coagulation of the blood, must operate so as to destroy the tendency of the lymph to combination or organization. Hence, in inflamed parts, where there is a considerable quantity of blood, there is an increased deposition of lymph, and consequently often a painful increase of irritability and sensibility. This, however, does not take place when the deposition of the lymph is in the cellular membrane, as in schirrus tumors. But to return from this digression."

"When the blood is propelled to the small capillary vessels, in consequence of fibrous action (which is the only effect of fibrous action we perceive) the circumstances necessary for its continuance in the state of arterial blood no longer exist. On arriving at the commencement of the veins, it takes on the properties peculiar to it in that state of parts *by the exercise of its affinities*, and is thus converted into blood. Here we see the agents, the solids of the part and the blood, as in the cases first mentioned. As the solids remain unaltered, the effects we should refer to the exercise of the natural affinities of the blood in the parts, just as we do the various shapes of water, eggs, and all other substances in other circumstances."

"If the above be correct, we are led to look upon the body as a laboratory in which the most important operations are performed. From the differences in its construction, we naturally conclude that various compounds are formed. And accordingly we find that different processes go on, and that compounds different from venous are formed from arterial blood. These are the secretions so familiar to us all."

"Physiologists, in accounting for the secretions since the rejection of the explanation on principles of mechanical filtration, have referred them to chemical changes wrought by the actions of the secreting vessels. The only effect of the action of a collection of vessels forming a gland, or a compound, that I can perceive, is to propel or convey the blood through it; and indeed it is to me incomprehensible, how the motions of simple tubes or vessels could possibly produce changes in any fluid. I shall, therefore, wave the consideration of the conjecture, and proceed to account for the phenomena on the simple principles suggested above."

" Although we be unable to detect the particulars in which one secreting vessel differs in its structure from another, yet on the slightest attention we can perceive a very material difference. We can readily discover that the very delicate hand of nature has made an astonishing modification of even the most minute vessels. From the various structure of all the glans, the blood when conveyed in them, assumes in each, in consequence of exercising the affinities peculiar to it in the respective states, the necessary forms and properties. Mr. Home observes, that immediately on leaving the vessels the secretions are fluid, and acquire their consistence shortly after. When the new properties are acquired, the ducts or other tubes convey them to the parts for which they were formed. It is thus I presume, *by the exercise of chemical laws, or affinities regulated by states, depending on the mechanism of parts, that the successive supplies of all the secretions are created from the blood.*"

" If this explanation be admitted, the vague conjectures of physiologists relative to secretion must be laid aside. In place of them we will have the plain facts, that nature was accurate and wise when she so made the solids of animals, that the fluids acquire in them by their own tendencies the necessary form and properties. Nor does she here demonstrate more forcibly, a delicacy and wisdom in operating, than in the structure of her master-piece *the eye.*"

" Our theory has something more than simplicity to render it plausible. It will enable us to explain several phenomena which have excited astonishment."

" The resemblance of all venous blood, coming from parts secreting very different fluids can no longer appear mysterious."

"The formation of an oily matter after death resembling spermaceti, and, also, other secretions are common occurrences. Fourcroy, by a particular process, was enabled to form bile from the blood of an ox, which has been erroneously supposed to be a proof of its being formed in the blood. It must readily appear from the invariable laws of matter, that whether the necessary circumstances for the formation of a compound exist in the body before or after death, or elsewhere are created by art, that such a compound would be necessarily created when the constituent parts are present. Hence this leads us to expect, that from the improvement of our arts, all the secretions may be formed by us at some future day."

"There is a fact familiar to most of us, which tends to prove the correctness of these opinions. This is the support which one animal receives from the secretions of another. It is true that some of these are more nutricious than others. This in some measure must proceed from a strong cohesion resisting the lesser tendency to assume the form necessary for nourishment. The secretions having a tendency to decomposition, afford a generous support, and fat and milk are among the most remarkable. When these are swallowed they are dissolved by the gastric juice, conveyed to vessels where they assume the form of chyle, and then pass on to the blood, and assume on the same principles its properties. Here we have, almost to demonstration, the same particles of matter in the shapes of a secretion, then chyle, then blood, in which last form it had existed."

"There is a system of vessels whose office to the body seems the reverse of that of the secretories. This is formed by the *absorbing vessels*, which may be termed the *supporting system*. While the first is engaged in diminishing the volume, the other is not less active in renewing the blood. It is through these vessels that chyle is formed from our food, and that all the secretions of our body, all tumors, effused blood, matter, &c. are returned to the blood. In this process we find nature adhering to her beautiful simplicity. By a proper and uniform structure of these vessels, the various substances on entering them, assume the same appearances in consequence of their natural affinities in that state, just as they acquired other properties under different circumstances in other parts. When these new properties are thus acquired, it is conveyed to the blood vessels, where it is changed from lymph to blood. It is in this manner, in continued fevers, where no nourishment is taken for weeks, that large quantities of blood are formed from the secretions, the absorption of which must be accelerated during the general increase of fibrous action. This is confirmed by the circumstance, that the animals in the north, during the winter, are entirely supported by the absorption of fat---a secretion deposited in their cellular membrane."

This is the theory by which we have accounted for vegetable secretions and growth; and also for the changes taking place in those bodies which have hitherto received most of the attention of the chemist. The uniformity, and I may add, the simplicity of the explanation or theory, appears to me an argument, in its favor, of no inconsiderable weight.

When animal substances are formed, they possess the characteristics of life only for a certain time; these are then lost, and the animal is said to *die*. After death their bodies soon putrefy; in consequence of which, numerous compounds are formed, which, as observed of vegetable bodies, depend on two causes; one is the particular elements present, and the other is the *circumstances* in which these elements are placed.

The putrefaction of animal matter takes place in proportion to the number of elements in it: that of a very compound nature going on much more rapidly than that which is composed of only two or three elements, as fat, resins, &c. However, whatever be the composition of animal substances, it is indispensably necessary that moisture and heat be present for putrefaction to take place; and in general the higher the temperature the more rapid is the putrefaction, provided the heat be not too great, in which case it carries off the moisture. It has also been observed, that putrefaction advances more rapidly in the open air; but exposure to the air is not *necessary*, although it modifies the process.

When putrefaction commences, the bulk, color, and consistence of the body are changed. Various aeriform bodies are extricated; these generally consist of ammonia, or the volatile alkali; of hidrogen air holding sulphur, carbon and phosphorus in solution; of carbonic acid, nitrogen air and water. Miasma and nitric acid are, in some cases, formed and emitted, and there remains behind an earthy-like substance.

In carcases buried under the earth, this process goes on more slowly. But when a great number of carcases are crowded together in one place, and are so abundant as to exclude the action of external air and other foreign agents; their decomposition is entirely the consequence of the action of the component parts on each other. The body is not then dissipated, but is found diminished in size, and converted into an oily matter, resembling *spermaceti*. This singular change has not long since been noticed.

About 1786, the burial ground of the Innocents in Paris, became so offensive, that it was found necessary to remove the numerous carcases which had been heaped on each other, to another place. On removing these, it was found that the flesh had been converted into this *soapy* substance, of a white color, soft and greasy to the touch. With alkalies it formed soap, and when set on fire, it burnt precisely like oil or fat, only that it exhaled a more unpleasant odour.

On examining a pit at Oxford, where all the bodies which had been dissected were thrown, Mr. Gibbes found the same substance. A small stream of water constantly passes through this pit; a circumstance which induced Mr. Gibbes to try if animal muscle exposed to the action of a running stream would undergo the same change. The experiment fully succeeded; and consequently he attempted to render this substance, to which he gave the name of *spermaceti*, useful in those manufactories which require tallow. And a manufactory for the purpose was accordingly established at Bristol. This product, however, is found to have a disagreeable odour, but no doubt this might be corrected; and then persons dying, may have the pleasing reflection, that their bodies instead of affording food for disgusting insects, will be exhausted in furnishing light for the illumination of elegant rooms, and other useful purposes.

OF COLORING BODIES.

IT now remains for us to make a few remarks concerning the art of

COLORING BODIES.

This may be divided into two branches; the one called *painting*, the other *dyeing* or staining. The art of painting depends, as observed while considering oils, on the application of one body, called a paint, to another. It is necessary that it should adhere to the body to be painted; and hence the paints or coloring matter are mixed with linseed oil, which on drying, acquires a considerable degree of solidity. The success of this art depends in a great measure on the degree of intimacy with which the oils and coloring matter are blended together.

The art of varnishing differs from that of common painting only in this, that the substance used as a varnish should reflect strongly the light, so that it may have a glossy or shining appearance. Concerning the method of making varnishes, we treated while considering the properties of resinous substances.

But the art of *dyeing* differs considerably from that of painting. It depends chiefly on changing and giving other reflecting surfaces to bodies; which can only be done by means entirely chemical.

Concerning the *particular means* of varying the reflecting surfaces of *every substance*, it would not be possible for me to dwell on in a work like this. Some of these means have been occasionally hinted at in the course of this work; and I shall now only mention the following. No substance is found to produce more considerable changes on the surfaces of bodies than the light of the sun.

The art of *bleaching*, or rendering bodies in that state in which they reflect the rays of light, so as to excite the idea of whiteness, appears to depend in great measure on the strong tendency which oxigen has to unite with bodies, and form a white compound ; at least this holds good with the products of the vegetable kingdom. Hence, the oxi-muriatic acid, when united with water, is frequently used to whiten many substances, as we before observed. This appears to act by yielding oxigen to combine with the dark colored body; and on the same principle the long exposure to air, to weak acids, to hot water, &c. of many substances is found to *bleach* or whiten them.

Cotton is bleached in some manufactories by the following process: to a boiler firmly fixed, a top is adjusted in a strong manner. Potash rendered caustic by lime is put into the bottom of this vessel, and the goods intended to be bleached, are put into a basket, which prevents their touching the sides of the boiler. When the articles are properly placed, the covering is then fixed on, which has a very small orifice, to allow of the escape of a part of the steam. By these means a degree of heat, much superior to that of boiling water, is excited in the solution of potash; and the heated water, aided by the potash, destroys the coloring matter of the cotton and leaves it of a fine white color.

It is found that it is not only necessary to bleach articles to be dyed, but to have them cleansed as perfectly as possible. And for this purpose they are usually washed in a strong solution of soap in water, which in some instances dissolves a portion of the substance of the article and thereby the better adapts it for being dyed.

The substances used have as dyes been classed under the two heads of *substantive* colors, and *adjective* colors, by Dr. Bancroft.

1. *Substantive* colors are those, the particles of which, of themselves have a sufficient affinity for the stuffs to be dyed, to unite to them and remain fixed.

2. *Adjective* colors are those which have not of themselves a sufficiently strong affinity to be fixed on the body, but require some earthy, metallic or other body, by which a bond of union is formed and the color fixed. The body interposed is called the *base* or *mordant*.

Before the coloring matter will unite to the stuff to be dyed, it is necessary that it should be in a certain state, which is created by its solution in water; and most commonly the presence of heat is also necessary. It may be well to call the water, heat, and any other article necessary, *agents*, as they are instrumental in creating the circumstances for the exercise of the affinities between the articles to be dyed and the coloring matter. These articles should be termed the *actors*. Therefore, for dyeing a body, there should be (what is necessary in all cases where the affinities of matter are exercised) first, a *state* for the exercise created by bodies, properly termed *agents*: and secondly, bodies which will act on each other in such a state, which are properly termed *actors*.

Of those actors in dyeing, which are called substantive, in consequence of not requiring any additional body to *fix* them on the body to be dyed, the most remarkable are the following: the husks of walnuts, the roots of the walnut tree, shoemake or sumach, santal, the bark of elder, &c. These are commonly termed *root colors*. No preparation is required to dye with these ingredients; nothing more being necessary than to boil the stuff in a decoction of these articles. The most remarkable dye of this kind, is the famous *Tyrian purple*, which is supposed to have been discovered 500 years before Christ, in Tyre, and obtained from certain shell-fish. It was, however, lost for many hundred years, and was again discovered in 1685 by Mr. Cole, in the shell-fish called the *buccinum*. The shell which is considerably hard, is first broken by a small blow, taking care not to crush the body of the fish within. After picking off the broken pieces, the juice is obtained from a small vein near the head, when it appears of a white color, and feels clammy. When this is applied to linen or silk and exposed to the action of the sun, it first appears of an emerald green, then changes to a blue, and lastly to a purple red. If the cloth be then washed with scalding water and soap, and exposed again to the sun, the color changes to a beautiful crimson, which suffers no further change from exposure to the sun. The *purpura*, and an abundance of snails are used also to dye the Tyrian purple. It is stated that the green fluid, obtained from the common tobacco worm, may be applied to useful purposes in the art of dyeing.

Among the articles used in dyeing, which may be called *adjective actors*, in consequence of requiring a *mordant*, or base, to fix the dye, the substance called *cochineal* is most remarkable.

This is a substance very generally known and used to dye a rich crimson color. It is a small, irregular, roundish body, and internally of a red color. It is obtained in great quantities from South America and St. Domingo, where it has been collected with such secrecy, that the source from whence it was obtained was long unknown. Acosta, Sloane, Plumier and other travellers have ascertained, that it is a small short lived animal, which is supported by eating the leaves of the prickly pear tree. They are taken from the plant, killed by boiling water, and are then dried with care in the sun. Several kinds are sold in commerce; but the best is somewhat heavy, of a grey color tending to a purple. When chewed, it tinges the spittle of a deep red color called crimson, and excites on the palate a faint disagreeable impression. When quite dry, it has no smell.

This article is much used to dye a scarlet color. For this purpose, several methods of preparation, &c. have been recommended. But all these have been superseded by what has been suggested by Dr. Bancroft. According to the Doctor, a beautiful scarlet color may be dyed by the following means, which will be found less troublesome and expensive than any other.

It is necessary to procure a quantity of a yellow bark called the *quercitron bark*, which is sold very low. A solution of tin in the nitric, or nitro-muriatic acid, is commonly used; but it is found far better to dissolve the tin in a mixture of the sulphuric and muriatic acids, formed by adding two parts of the first acid to three of the muriatic. The muriatic acid is to be first poured upon a large quantity of powdered tin in a glass receiver, and then the sulphuric acid is to be added slowly; when, by means of heat, the solution of the tin is expedited. This murio-sulphate of tin is perfectly transparent and colorless, and may be long preserved for use. This solution being prepared, the cloth to be dyed scarlet is to be put in a proper tin vessel nearly filled with water, with which about eight pounds of the murio-sulphate of tin is previously mixed; the liquor is then boiled with the cloth in it, which should be turned through it as usual for fifteen minutes; the cloth being then taken out, four pounds of cochineal, and two and a half of quercitron bark are to be added in powder; having mixed them well, the cloth is to be returned into the liquor, the boiling and agitation continued until the color is duly raised, and the dyeing liquor exhausted, which usually takes fifteen or twenty minutes. The cloth is then to be taken out and rinsed as usual.

A scarlet color may be given to *silk* by the following process. Let the silk be soaked for two hours in the above solution of tin, with five times its weight of water; then it is to be moderately pressed, partly dried, and then dyed in a bath of cochineal and quercitron bark, four parts of the first and three of the last. Should the color not be bright, the operation may be renewed. By omitting the bark and dyeing the silk (prepared as before) with cochineal only, a very lively rose color may be produced.

Cotton may be dyed scarlet, by soaking it in the above solution of tin, as proposed for silk. The superfluous part of the solution is to be wrung out, the cotton should then be plunged in water, in which as much clean potash has been dissolved as will neutralize the acid still adhering to the cotton, which is then to be rinsed in clean water and dyed with cochineal and quercitron bark.

The article called *gum lac*, is a species of wax which forms the cells of a certain insect. It owes its beautiful red color to the insect. It is used to color sealing wax, red morocco; and for several of the purposes to which cochineal is applied.

But as before observed, it is not consistent with the plan of this work to enter into particular details concerning the art of dyeing. In fact it would require a volume to give one half of the particulars; for the means of varying the color, or *reflecting surfaces of bodies* are innumerable. Each dyer will be found to have some particular, peculiar to himself. In such processes, care should always be taken, to notice accurately what substances are requisite, their exact proportions, and the state which should be created by water, heat, light, &c. for these substances to operate on the surfaces of bodies. Unless these be attended, *experience* will prove of no use, and every trial will be found varying.

☞ *The following address I delivered before the Philadelphia Medical Society, at their session in* 1804, *for the privilege of being an honorary member of that respectable institution. The doctrine it endeavors to support, is, that animal life is not in consequence of the agency of an intelligent spirit, called vis medicatrix, which regulates the motions of the body, as supposed by one set of philosophers ; nor in consequence of its being the effect of " stimuli acting upon the excitability of the system," as taught by their successors ; but that it (life) is in consequence of the affinities of matter exercised on each other, when the necessary states are created A p rt of the doctrine here advanced was first introduced into the Medical Society by the accomplished, and not less learned than eloquent, Dr. N. T. Chapman, formerly of Virginia, and at present one of the practitioners of physic of Philadelphia. It was solely with a view to lead to an investigation of the merits of the doctrine that this paper was prepared, and with that view it is now offered as a*

CONCLUDING ADDRESS.

GENTLEMEN,

THE detection of error has been almost uniformly considered as a step towards the attainment of truth. Influenced by this impression, many of the first philosophers have recommended remaining without theories,inpreference to the adoption of such as are unfounded. Observing the tendencies of the mind, they could not fail remarking, that the attachment to ideas was proportionate to their duration. But few causes have proved greater barriers to the prosperity of science than such attachments: they have lessened the energies of its prosecutors, and have prevented the prevalence of more noble feelings. And men not animated by an adoration of truth, but yielding to the dictates of inclination, could not fail to be early plunged in the boundless ocean of uncertain conjecture. Here the semblance of truth, attracting on all sides, constantly dazzled and deluded the most daring navigators. Neglecting the surface, and diving towards the impenetrable recesses of nature, they could only give the ravings of *misguided* speculation. The general and false glare serving to fascinate the students, successively bewildered them too in the mazes of intricate theories! Hence ages have been marked only by the accumulation of error! Hence confusion, delay, and wild suggestions, have characterized the progress of science!

In taking a retrospective view of the attainment of our small stock of knowledge, we have but a sad portrait of the mind of man. On the one side we behold the feebleness of his power---on the other, the folly of his plans. At one time we find him grasping at the intelligence of a Deity---at another, in the convulsions of prejudice opposing truths accidentally revealed. At one time we find him struggling under the pressure of difficulties---at another, exerting his powers in lessening the influence of enlightened benefactors! These mournful circumstances have militated most against the medic art. The dignity of the science has been debased, and its pillars ignorantly mistaken. But few within these walls are unacquainted with many of the groundless theories and absurdities which have engrossed the attention of physicians. But few have not felt varying emotions on reading the details of the follies, the contentions and the misfortunes of the faculty. Even in our own days, are to be seen unhappy effects of a want of proper ruling principles, and of unanimity among our brethren. Ye young philanthropic votaries! while you weep over the melancholy retrospect, you should not be unmindful of modern scenes! you should make an advance! you should exhibit an example calculated to reclaim such lamentable perversion! At once sever yourselves from contracted habits, and your souls will regale on the inexhaustible luxury of serving mankind.

In early days, when the understandings of physicians were uncultivated, in consequence of the general ignorance, we should not be surprised at the frivolous theories obtruded occasionally on the world. But that a period of many hundred years should roll on, marked by revolutions without number, and no determinate point be fixed, is a subject of astonishment. We should not, however, be surprised that while their enquiries were veiled under the shroud of superstition, that an invisible spirit, a Godlike power, should be called in to explain the phenomena of life. But that men, when freed from such frights of fancy, would persist in supporting doctrines of an intelligent power ruling the body; that they should voluntarily entangle themselves by entering the labyrinth, and following the windings of little gods, of their own creation, is truly unaccountable. Fortunately, however, the cause of the spirits was forsaken early in the last age. There then arose a BROWN, possessed of a superior mind. To the boldness of originality he added profundity of research, which enabled him to dissever the fetters entangling the doctrine of animal life. Scarce had the brilliant labors of this illustrious benefactor of the world been known, before new irradiations broke forth. The favorite votaries of chemistry felt the flash. Their minds expanded at the vivifying impulse; they acted, and the value of their works is daily increasing. The science, though but in its infancy, is eminently conspicuous. Already has it revealed many of the late arcana of nature.

Among the vague conjectures of ancient or of modern times, but few are possessed of more plausibility than those of the once celebrated des Cartes. His system of the planetary motions, although arrayed in all the pomp of mathematics, has not escaped a proper exposition. The detection of its fallacy, and the divine satisfaction of discovering the true principles, were reserved for the sagacious Newton. It was he who correctly observed the motions, and referred them to the attractions; to the laws of matter. And much is it to be regretted, that the study of such laws has not been more universally the delight of his successors. Physicians it seems, became either blinded by the brilliancy of his labours, or were too fond of mysteries, to descend to the consideration of the simple laws of the matter around them. The failure of all their trials, might at least have taught them where it was folly to travel. So far from explaining the operations of animal bodies, they have been unable to draw lines of distinction between the animal and vegetable kingdoms. Nature knows nothing of such distinctions: artificial separations she refuses to admit. The striking similarity stamped on all her productions, unquestionably displays the uniformity of her manner of operating. Her circle of decompositions and recombinations, effected entirely by the affinities of matter, demonstrates the extent of her power, while it announces the importance of the bodies around us. Let us turn our attention to some of her works and contemplate the excellence of her ways.

An alkaline solution is placed in a vessel before us. If to this an acid be added, an action will ensue, a new substance will be formed, and its qualities will essentially differ from those of the ingredients. So it is when you pour alcohol on a concentrated acid in a certain degree of heat. These substances act on each other, and the remarkable compound, ether, is generated, The burning of a candle before us, is on the same principle. The tallow, in a high heat, attracts and unites to the oxigen, at which time heat and light are set at liberty. Every one agrees in referring these and similar changes to the attractions, or affinities, or laws of the respective bodies, in the states in which they are applied to each other : and we might term the union of the substances the *generation*, the sensible action the *life*, and its duration the *period* of existence.

In the vegetation of plants we are equally struck with such phenomena. We place a particle of matter peculiarly organized, called a *seed*, in a mixture of earths, carbon and water, termed a *soil*; and through the agency of a moderate heat, these particles act on each other : the seed attracts and combines with portions of the bodies around it, by which its bulk becomes enlarged, and all its properties are changed. The bulk of this newly formed mass will depend on the structure or arrangement of the constituent parts and the weight on the quantity of substances attracted from the earth. The superior parts of the plant on coming in contact with carbonic acid attract and combine with its carbon, while its oxigen is disengaged for the respiration of animals. The plant being formed by the exercise of affinities in a certain state, readily has these affinities varied by change of state or circumstances. Hence, vegetable bodies are found in the cold seasons to be materially altered. Hence, in the fall they frequently wither and die. A part of their carbon unites to the oxigen of the surrounding air, forming carbonic acid to nourish other plants in future times, and the remaining parts fall down, and re-combine with the earth in states of combination depending on accidental circumstances Such operations are explicable, without the forced interposition of any vital principle, excitability, or any other imaginary quality. The phenomena are obviously the effect of the affinities of matter, exercised in the various circumstances or states. Why then follow the common custom of calling in the agency of any unnecessary principle or property? Shall we not follow the valuable advice of Lord Verulam? Shall we contrary to the first rudiments of philosophy, reject the most simple explanation of facts?

Let us extend our views a little farther; we will find animals unquestionably formed by the affinities of matter. For this, we must recal to our minds the experiments of Count Rumford, and the Abb Spallanzani. The former gentleman boiled for some time, a quantity of vinegar, and during the ebullition, glass vessels were filled with it, and then hermetically sealed. After remaining in this state at rest for several days, the Count discovered that a number of little animals had been formed in the vinegar, and were traversing the fluid. These animals are here the more readily produced, as the acetic acid may be easily decomposed, so that its particles may react on each other. But the experiments of Spallanzani are still more decisive. Being repeated frequently and related with the habitual accuracy of this celebrated naturalist they can be strictly relied on. In a number of small glass vessels, he put equal quantities of seeds, filled them with water, and then hermetically sealed them. They were all subjected to great degress of heat for different periods. After they had undergone the action of the heat, they were laid aside for several days.

On examination, this excellent philosopher invariably observed that the number of animalculæ formed in the vessels, was proportionate to the *duration* of the heat to which they had been subjected. The seeds, for example, boiled two hours, contained four times as many animals as those boiled but thirty minutes. Here we see the recombination precisely proportionate to decomposition. Surely, the animals were formed by the action of the particles of the matter on each other; for what germ could have sustained so great a heat, or what vital principle could resist so powerful an action?

The worms found in the kidneys, livers, and other parts of animals, further confirm this doctrine. It is too great a stretch of the imagination to suppose that a germ could be taken into blood vessels, circulate through the whole system, and then accidentally be deposited in parts properly adapted for its growth. According to our theory, these insects are formed by the combination of certain particles of matter coming in contact, under the proper circumstances created in the body.

It being thus almost demonstrated, that animals of the inferior class may be created by the action of matter on matter, we will glance at a higher order; we will advance to view the formation of man himself. The embryo cannot be prepared, every one knows, without the union of male an female secretions, requiring I believe not only the existence of the necessary circumstances, but the presence of oxigen air. The early re-action, the subsequent union with the maternal blood, and the consequent increase of bulk, are the effects of affinities; the particulars of which we cannot at present explain. We can only now account for a few of the processes in this complex apparatus. After birth, the lungs act as a chimney place to the body; for there the blood absorbs oxigen which at the time loses a part of its latent heat, which is afterwards further lost by the changes wrought in the blood in different parts. The stomach is a vessel serving as a retort, in which the food is dissolved by a fluid before it can nourish the body. The fluids sometimes acquire an unusual capacity to combine with sensible heat; and hence the body suddenly feels very cold. All the secretions of the body also appear to be the effect solely of the exercise of the affinities of the fluids, in the various states existing in the machine: a decomposition and recombination are constantly going on in the body. The formation of the teeth is universally known to be the effect of a pure crystallization of the phosphate of lime. And to a kind of crystallization are we to attribute the coagulation of pure blood when at rest.

In diseases we have instances of such chemical operations still more obvious. Diabetes is characterized by the chemical union of carbon, hidrogen and oxigen, forming sugar. In gout, we have concretions or crystals of the lithate of soda. The urinary, biliary, and other calculi, found in the body, must assuredly be formed in the same manner. And the ulceration of muscular fibres, is known to arise in a great measure from their combination with the oxigen of the air, forming fetid compounds. In a low degree of heat, called the extreme of cold, we know that the fluids strongly re-act on each, and acquire the appearance of a black mass; a process called mortification.

If this theory be admitted, we perceive at once the similarity of nature's manner of operating. She has given to matter, laws, which come into action when under certain circumstances: by varying the quantities of this matter, in a great degre, and by still more varying the states or circumstances in which it produces effects, she has made ample provision for forming her innumerable productions from the combinations of bodies to unite to plants, up to the combinations for the head of man. Once, gentlemen, familiarize yourselves with the idea, and it will appear as surprising, that the fine fluids, heat and light, should be extricated, when oxigen combines with carbon, as that our intellects, stated to be portions of an ethereal spirit, should be separated from the blood, when brought into the delicately organized vessels of the brain, by laws peculiar to itself.

If this theory be admitted, how much ought we to value our powers! how wide are the fields for experimenting! To form any product, all that we have to do, is to create the necessary state, and add the necessary articles which experience teaches to be proper. The sole objects then of a chemist, are first to know precisely the constituent portions of a compound, and then to acquire the art of forming the particular circumstance for such portions to act on each other. When indulging our imagination, and viewing what chemistry was a few years back, and what it now is; where can we set bounds to our expectations! You know that the science is but lately freed from the fetters of Egyptian hieroglyphics; its embryo is just emerging from the troublesome trammels of alchemy. The conductors now cherished in the bosom of nature; almost omnipotent, because united, will not be retarded in their progress. Let their successive generations go cordially hand in hand, and atonement may soon be made for the misdirected industry of ancients. A knowledge of all the laws of matter may yet be acquired: and then we will find persons vieing with nature in forming the most valuable productions. Nor will active and revolutionary man rest with such success! Growing tired with the tardy operations of nature, he will seize at once her agents, and will in a few moments combine them, thereby forming all the articles used as the necessaries and the luxuries of life. Perhaps too he may progress still more. By a zealous industry, and cordial union, possibly he may be able by his art to prepare the state, to ascertain the constituents, to apply them together so as to crystallize a man! All other collateral branches will proportionably improve. And when a man is thus formed, the artists may be able to rob the heavens of their electricity; to convey it at pleasure through our immense mines of carbon, converting them into diamonds, and with these erect a refulgent mansion for his earthly residence!

DEFINITIONS

OF THE

TECHNICAL TERMS

UNAVOIDABLY USED IN THE WORK.

A

Acetic acid. This is the acid which gives the sourness to vinegar.

Acetates, are the substances containing the acetic acid.

Acetous acid, is an acid containing less oxigen than the acetic acid.

Acetites, are the substances containing the acetous acid.

Acids, are sour substances possessed of certain general properties, enumerated page 101, of which there are three kinds, the mineral, animal and vegetable.

Affinity, chemical attraction, a law of matter.

Air, an invisible fluid, our atmosphere is an example. Great varieties of it.

Aeriform, } existing in the state of airs.
Aerial, }

Albumen, the name of a part of animals resembling the white of eggs.

Ammonia, the volatile alkali.

Alcohol, pure ardent spirit.

Alkalies, substances possessed of certain general properties, enumerated page 145.

Alumine, name of an earth.

Alum, a neutral salt, formed by the sulphuric acid and alumine.

Aloes, name of a vegetable substance.

Alloys, the name of compounds of metals.

Amalgams, the name of alloys containing mercury.

Apparatus, any particular machine.

B

Balsams, vegetable bodies, formed by an oil and a resin.

Bases. This word is used in different senses by chemists. It signifies the chief part of compounds: we have bases of the airs, as nitrogen, oxigen, hidrogen, &c. bases of acids, as phosphorus, sulphur, or any substance which unites to oxigen so as to become acid; then we have the bases of neutral salts, which are all the substances that unite to the acids: and lastly, we have the bases or mordants of dyes, which are articles used to fix the dye on cloths.

Bleaching, making white.

Brewing, preparing fermented drinks.

C

Calx, a metal united to oxigen, called oxid by chemists.

Combustible, may be burnt, inflammable.

Caloric, the name of heat or fire,

Calcareous earths, of the nature of lime.

Carbon, the name of a substance which when pure is called diamonds.

Carbonic acid, an acid formed by the saturation of carbon with oxigen.

Carbonates, are neutral salts containing carbonic acid.

Charcoal, an oxid of carbon.

Citric acid, the acid of lemons.

Coagulation, rendering hard.

Crystallization, conversion into particular shapes.

D

Detonation, explosion.

Ductility, capability of being drawn into wires.

Dissolve, is to chemically combine a solid with a fluid.

Dyeing, changing the reflecting surfaces of bodies.

Decoction, water containing part of a vegetable substance dissolved by means of heat.

Distilling, separating volatile substances by means of heat.

E

Effervescence, is the escape of an air from a solid so as to make a kind of hissing noise.

Elements, are bodies which cannot be decomposed.

Ether, is the name of a volatile compound, formed by the union of an acid and alcohol.

Evaporation, is the carrying off a body by means of heat.

Earths, are substances possessed of certain general properties enumerated in page 169.

F

Fermentation, is a process depending on the re-action of the constituents of a compound fluid.

Fulmination, detonation or explosion.

Fluates, neutral salts containing the fluoric acid.

Fibrina, the name of a substance found in the blood, and forming a part of many animal bodies.

Fecula, the name of a substance found in vegetables, called also starch.

Fusible, which may be fused or melted, or made fluid by means of heat.

G

Gas, an air.

Gazeous, aeriel or aeriform.

Gastric juice, a secretion from the stomach.

Gluten, the name of a substance forming a part of vegetable bodies.

Gelatine or *jelly*, the name of a substance forming a great part of animals. When nearly pure it is called glue.

Galvanism, is a fluid also called animal electricity.

H.

Hidrogen, the name of a substance generally obtained by the decomposition of water.

Humid, wet.

I

Indigo, the name of a vegetable substance used in dyeing.

Isinglass, the name of a substance obtained from whales.

Inflammable, may be burnt, or combustible, or oxidable.

An infusion, water containing part of a vegetable in solution.

L

Laboratory, a place where chemical operations are performed.

Lava, a substance emitted during the eruption or burning of volcanoes.

Latent, hidden, combined, insensible.
Lutes, substances used to connect vessels together.
Lustre, reflection of light.

M

Malic acid, acid of apples.
Malates, neutral salts containing the malic acid.
Muriatic acid, the name of an acid obtained from common salt.
Muriates, are bodies containing muriatic acid.
Mucilaginous, containing *slime* or *mucilage*.
Miasma, name of the substance causing fever in animals, and called contagion.
Mordants, bases or articles used to fix dyes.
Metallic, of the nature of metals.
Musk, an animal substance.
Mineralogy, relating to minerals.
Minerals, bodies obtained from the earth.
Metallurgy, the art of reducing or assaying ores.

N

Nitrogen, the name of an elementary substance obtained from nitre.
Nitric acid, an acid commonly called aquafortis.
Nitrates, neutral salts containing nitric acid.
Neutral salts, are compounds formed by the acids, and the bodies or bases to which they unite.
Native metals, are those found in a pure state in nature.

O

Oxigen. This is the name of the elementary substance which readily unites to other bodies, forming in some instances *acids*. It is supposed to be the cause of all acidity.

Oxids. These are substances which contain oxigen, and are not acid. The metallic bodies form the most remarkable oxids, which are named according to the metal: hence, we have the oxid of iron, oxid of tin, &c.

Oils, are substances possessed of general properties familiar to every one. Those obtained from vegetables are called fixed, or expressed, and essential, or distilled oils.

Ores, are minerals containing metals.

P

Process, manner of operating.

Precipitate, is a substance thrown down from its solution in a fluid by the addition of another.

Precipitant, is a substance added to precipitate another.

Pyrometer, is the instrument to measure the degree of heat: invented by Wedgwood.

Pneumatic apparatus, is a machine used for airs, represented in plate II.

Phosphorus, the name of an element.

Phosphates, neutral salts containing phosphoric acid.

Pyrites, are ores containing sulphur, called also hepatic ores and sulphurets.

Pottery ware, vessels made of earths.

Putrefaction, decomposition depending greatly on the re-action of the constituents of a compound, as fermentation; and is characterized by the emission of ammonia.

R

Rarefaction, dilatation by means of heat.

Retort, a vessel represented plate II.

Resin, a substance obtained from vegetables.

Respiration, breathing.

Refrigerator, a vessel for cooling.

Receivers, are vessels destined to receive the contents of other vessels.

S

Salts, are substances remarkable for their solubility in water.

Specific gravity, is the relative weight of a given bulk of matter.

Solution, is a fluid containing a solid dissolved in it, or chemically united.

Saturated solution, is one which will dissolve no more of a solid.

Solar phosphori, are substances which emit light in the dark without heat.

Sublimed, raised by means of heat.

Sacharine matter, sugar.

Sulphates, are neutral salts containing sulphuric acid.

Soaps, are compounds formed by oils and alkalies.

Sebacic acid, acid of fat.

Suberic acid, acid of cork.

Succinic acid, acid of amber.

Silicious earth, is silex, more properly spelt *silecious*.

T

Torrefied, roasted in the open air.

Tincture, is ardent spirit containing some part of a vegetable in solution.

Thermometer, an instrument to measure the degree of heat.

Tannin, is a substance which unites to the gelatine of hides forming leather; and the process is called *tanning*.

V

Volatilized, that is evaporated by means of heat.

Volatile, readily evaporated.

superior cast, who in the skilful management of all the beauties and energies of the English language, delivers his opinions

" In thoughts that breathe, and words that burn."

" There are limits to the human genius, which bound the exertions even " of the most comprehensive and vigorous mind—those limits we do sin- " cerely think Mr. Curran has, in innumerable instances reached."

Charles Fox has been considered the greatest orator the world has ever produced, yet it is thought by many, that Mr. Fox would be completely rivalled, if not totally eclipsed, by the brilliant and powerful eloquence of Mr. Curran, should their talents ever be tested by a competition in the same assembly.

LIFE OF CUMBERLAND.

BRISBAN & BRANNAN, *have lately published in an elegant octavo volume, price two dollars in boards, an entire new work, entitled memoirs of Richard Cumberland, written by himself, containing an account of his life and writings, interspersed with anecdotes and characters of several of the most distinguished persons of his time, with whom he has had intercourse and connexion.*

The above work is one of the most interesting publications that has appeared for many years, and in point of style, is far superior to Boswell's Johnson. The fund of anecdote relating to the private lives and *table talk* of lord Mansfield, Burke, Sackville, Garrick, Johnson, Jenyns, Foote, Goldsmith, and many other eminent characters, will be found irresistibly captivating. To those who are acquainted with the writings of Cumberland, it is useless to pass any encomiums on the present work, as the elegant productions of this amiable and celebrated author, will continue to be read with pleasure and delight, so long as refined taste, tender sentiment, and chaste composition shall continue to be cultivated, and admired by the literary world.

LIFE OF MALESHERBES.

BRISBAN & BRANNAN, *have just published, in a neat duodecimo volume, price* 88 1-2 *cents, bound, a work of uncommon merit, entitled, The Life of Lamoignon Malesherbes, formerly first president of the court of Aids, and French minister of state, during the reign of the last king Louis. The celebrated man whose life is here delineated, has acted too conspicuous a part both before and since the French revolution, not to interest every class of readers—a man who was one of the most illustrious martyrs of revolutionary cruelty—one whose life is a model of firmness, of loftiness of soul, and of all that the sublimest virtue can exhibit.*

The following observations on this excellent little production are extracted from the London Monthly Review. " These pages exhibit the outlines of a character distinguished most eminently by purity and worth, and at the same time recommended by all the advantages which are conferred by family, rank, and accomplishments, both elegant and solid.

Sparrow John
September 9th