

**An inaugural dissertation on the chymical analysis and operation of vegetable astringents, with observations on the identity of the vegetable acids : submitted to the examination of the Rev. John Ewing, S.T.P. provost ; the trustees and medical professors of the University of Pennsylvania, for the decree of Doctor of Medicine / by John Willis, honorary member of the Philadelphia Medical Society.**

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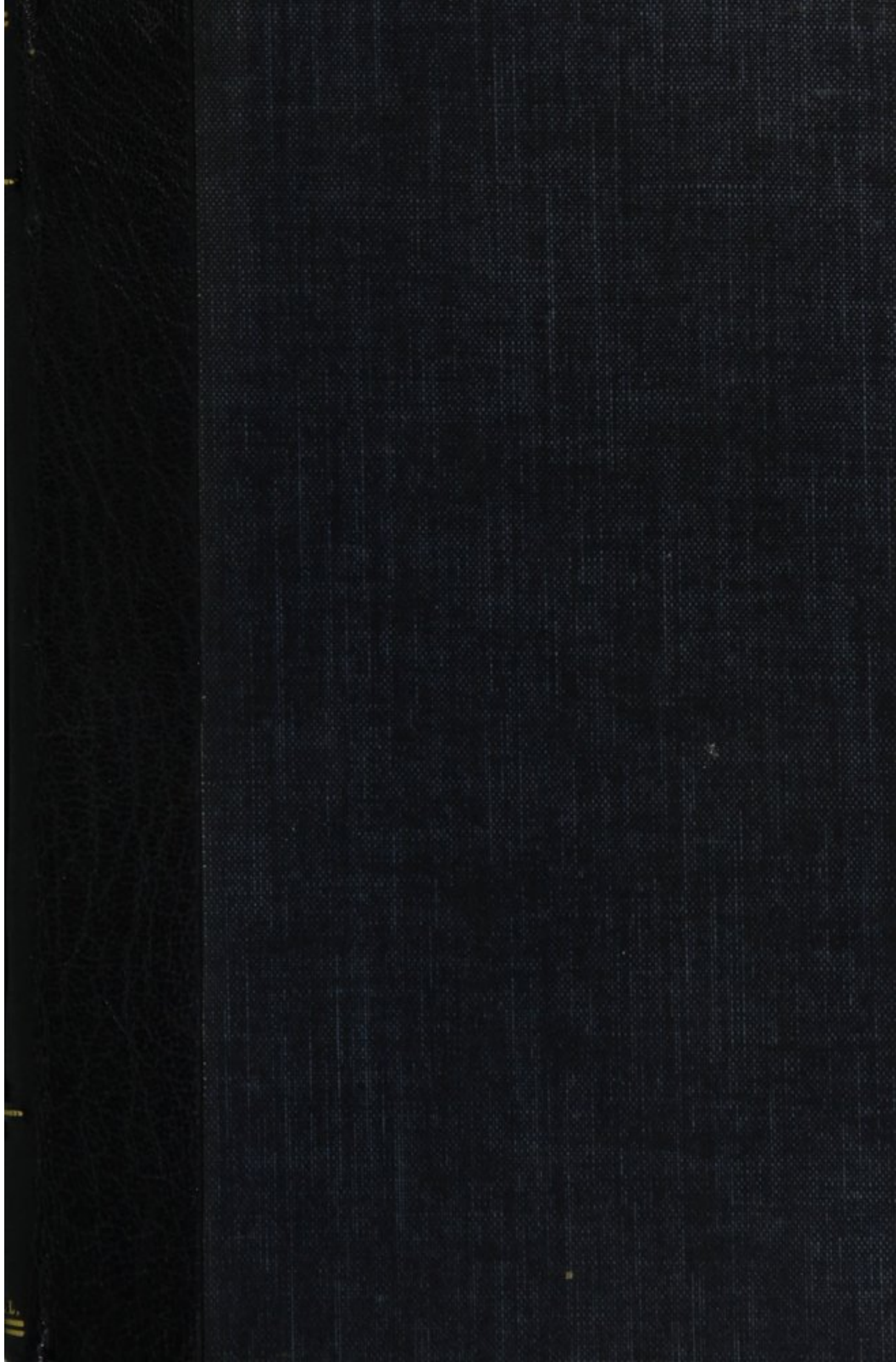
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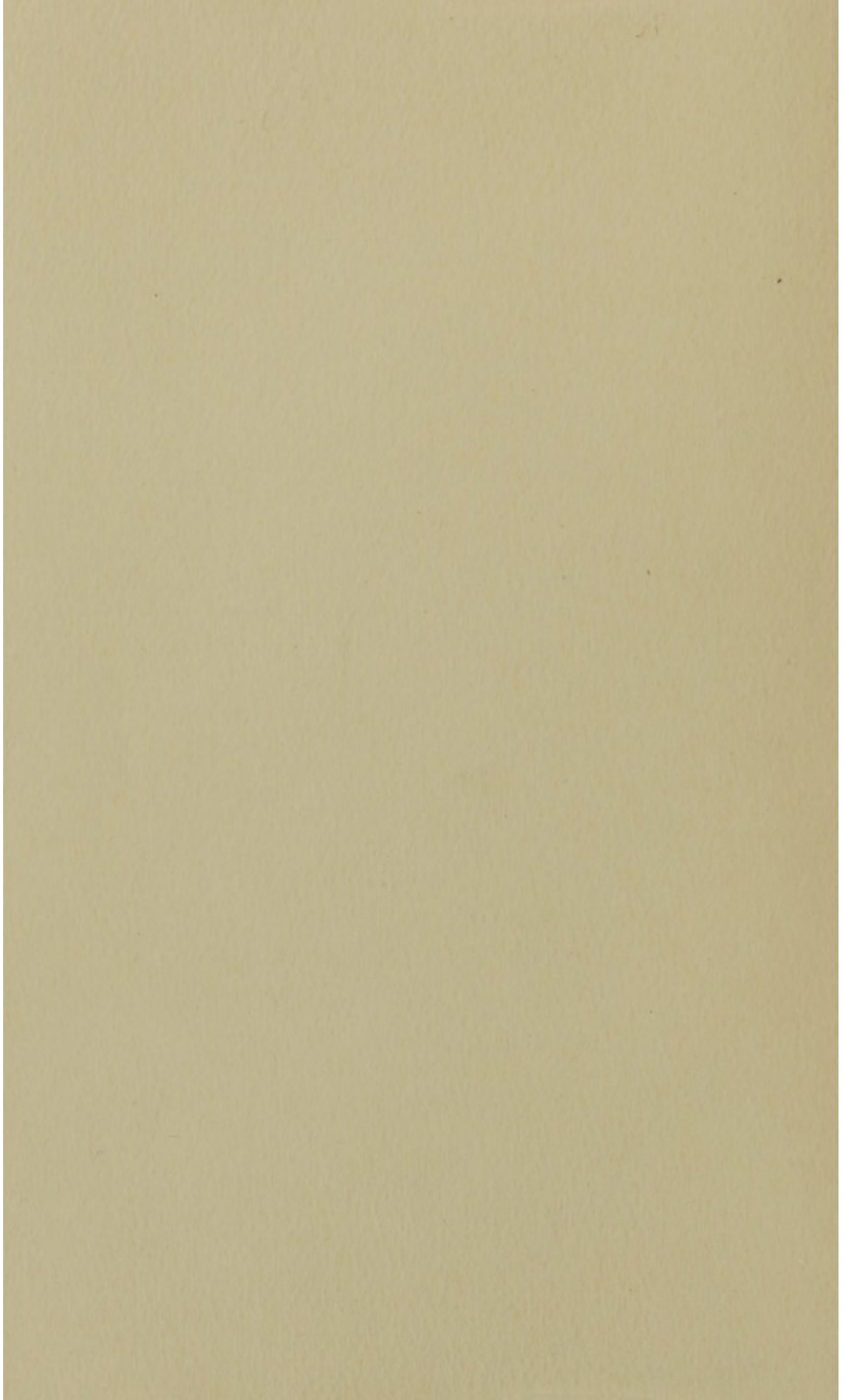
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AN  
INAUGURAL DISSERTATION  
ON THE  
CHYMICAL ANALYSIS AND OPERATION  
OF  
VEGETABLE ASTRINGENTS,  
WITH OBSERVATIONS  
ON THE  
IDENTITY OF THE VEGETABLE ACIDS;  
SUBMITTED TO THE EXAMINATION OF THE  
REV. JOHN EWING, S. T. P. PROVOST;  
THE  
TRUSTEES AND MEDICAL PROFESSORS  
OF THE  
UNIVERSITY OF PENNSYLVANIA,  
FOR THE DEGREE OF  
DOCTOR OF MEDICINE,

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By JOHN WILLIS,

HONORARY MEMBER OF THE PHILADELPHIA  
MEDICAL SOCIETY.

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OPINIONEM COMMENTA DELET DIES, NATURAE JUDICIA CONFIRMAT,  
SIC.

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PHILADELPHIA:  
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PHILOSOPHY 101

LECTURE NOTES

BY

JOHN W. DEWEY

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# P R E F A C E.

**A**N attempt to the further investigation of vegetable astringents ; after the very valuable publications of doctors, M'Bride, Percival, Irving, and many others ; has the appearance either, of a disapprobation of their opinions, or an expectation of saying something more valuable on the subject. However, I would observe that the detection of error in medicine, is never the result of a harmony of opinion, (which seldom exists among Physicians,) but is always the offspring of minds, fluctuating between a variety of opposite sentiments : And thus it would appear, that the variety of systems, and opposition of opinions, which prove a perpetual source of private dissention, instead of impeding the science of medicine ; as some have asserted ; rather quicken its progress, by banishing all belief of infallibility, which we find so often fostered by blind veneration.

As this science is founded on experience, and observation, it must continually be in progressive motion, and therefore subject to perpetual change, in proportion as new facts arise, and new observations present themselves ; from whence it has received the stigma of conjectural art ; however, this is far from being just ; for all the principles in medicine, which arise from observation, and experience are as true as any in chemistry, or mechanics. But we find it impossible to erect a system on observation, and facts alone, unmixed with little speculative notions ; for while experience points out to us the relation of things, it imperceptibly leads the mind, to the exercise, and display of the ima-

gination. There are some men, who carry this to excess, and by applying their favourite principles, on all occasions, beget theories in their closets which grow up in secret retirement, without ever receiving the smallest ray of observation.

We cannot but view with astonishment, the products of the overheated imagination of some theorists, whose minds appear to be constantly in quest of some gleam of fancy, to favour and support opinions prematurely formed; and will follow their propensities through all the dark roads of Hypothesis, being perfectly blind to the most illuminating facts. The reason of such men does not deceive them; they deceive themselves, and suffer their wills to be determined by false motives; here "man is at once his own sharper, and "his own bubble."

These are the men who seem rather to circumscribe the sphere of Medicine, than extend it; and it appears fortunate for mankind in general, that the existence of their theories have been but transient, and their errors soon corrected by subsequent observation.

However, I had rather pay these theorists the tribute of esteem due them, than be guilty of an outrage on their labours. For though their imaginations are so lively as not to be confined within the narrow limits of facts, and their luxuriency of fancy incapacitates them for deliberate observation, they have been always men conspicuous for genius and quickness of apprehension; and very justly deserve to be ranked among that small number, which the Author of Nature has distributed from time to time among the societies of men, on whom he is graciously pleased to bestow a larger portion of ethereal spirit, than is given in the or-

dinary course of providence. They appear to engross nearly the whole reason of the species, and seem to have been born to instruct, to guide, and to preserve; and are therefore designed to be the tutors and guardians of mankind. When they prove such they exhibit to us examples of the truest virtue and piety, and deserve to have their festivals kept; instead of that pack of anachorts and enthusiasts, with whose names the calender of Medicine is disgraced. But we often find, on the contrary, these superior parts employed to do superior mischief, and a misapplication of those parts that were given for the good of mankind is committing a most sacrilegious breach of trust; it is perverting the means, defeating, as far as lays in their power, the designs of providence, and disturbing in some manner the system of infinite wisdom.

But an exclamation against theory is by no means a proof of earnest zeal for observation, and when theory is the offspring of observation, and not the luxuriant growth of fancy, it does not mislead the inexperienced, by pleasing the imagination, but rather guides their footsteps and illuminates their paths. Thus, it would appear, to reject all theory from medicine, would be at once offering every obstacle to the natural progress of the science.

Vegetable astringents like most other medicines, have undergone great revolutions: in some ages being in high repute, their operation on the solids have been studied and keenly pursued, while in others they have been as much neglected.

To take a survey of the several Hypotheses, which have prevailed at different times, would afford a melancholy proof of the ridiculous nature of most of them, which have been pursued through



the treacherous ways of conjecture, without discovering the least ray of light: it would at the same time be a task not less arduous than an attempt to give a history of the caprices of the human mind. But as I before observed, they have been all short-lived; some have perished of diseases which, in a manner, they brought into the world with them, and were of course soon buried in oblivion; whilst others supported by stronger powers of imagination have excited great admiration, and appeared, for a short time, to stand on a firm basis, but in succeeding ages have fallen a sacrifice to some other, which, being more novel, has struck the fancy of men as being more plausible, and we find there are none which have stood the test of an impartial scrutiny.

In the doctrines of astringents there appears to have been always a confusion of truth and error; therefore to separate the former from the latter, to make them plain, and above all to point out their useful application, is certainly the most laudable attempt of every observer. It shall be the object of my ambition; and to this end, I have avoided as much as possible all theoretical discussion, being sensible that it is only a careful collection and candid relation of facts which can approximate us to truth.

I have endeavoured to collect facts relative not only to the analysis and operation of the astringent principle of vegetables, but likewise to the identity of their acids, and have not been satisfied with a bare relation of circumstances, but have applied them to investigation, as fully as the nature of the piece and the time necessarily prescribed would permit: but I must appear under every disadvantage which can arise from want of time not only to rectify my thoughts, but even to throw them properly on paper.

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# ANALYSIS

OF THE

## *ASTRINGENT PRINCIPLE.*

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**C**HEMISTRY; In illuminating many parts of nature, by unveiling her beautiful order, and representing the true disposition of things, which, previous to the practicing of that art, was wrapt up in mystery, and confusion; has not failed to throw considerable light on vegetable astringency. But though chemical Analysis, that is resolving or taking down compounds into their most simple parts, is the method, which has generally been used in the inquiry of vegetable astringents ever since the time of Galen, and even before that period; yet we find that the composition of the astringent principle has remained unknown to chemists until very lately. However of late, it has been found to be composed of an acid, partaking of the properties of other vegetable acids, united with an earth called alumine or the earth of alum, forming a neutral salt.

That this may be looked upon as a constant law of nature. is proved beyond a doubt not only by analysis but synthesis: for we are not only able to decompose the astringent principle, but may recompose it by uniting the earth and acid, and by that means from an artificial compound no less astringent than the natural one.

But we are still very far from possessing a knowledge of the astringent principle, in any considerable degree of extent, and precision. We only know the elements of which it is composed. without ascertaining the proportions, necessary for its composition; by which we might be able to understand its constitution. The subject however seems to be capable of an investigation by further experiments, and observations; and at present we must conclude from analogy that the power of all astringents is in proportion, as the principle arrives nearer to the point of saturation.

This salt thus formed being found to be the cause of astringency; I shall consider it as the grand astringent principle of the vegetable kingdom, without a portion of which no vegetable in nature shews the least astringency to the taste; though it may perhaps strike a very black colour with sulphat of iron or green vitrol; which has for a long time been the fallacious test made use of to ascertain the astringency of vegetables.

Galls is a vegetable substance, (if it may be so called,) which exhibits the principle of astringency in a state, much nearer approaching to purity, than any we are yet acquainted with: and have therefore very justly stood for some time at the head of vegetable astringents: but its being in a manner the production of an animal is a character, which prevents its being assimilated to any known species.

It being ascertained that the astringent principle is a neutral salt, composed of an acid and an earth: the next question, that naturally arises, is, why are some vegetables more astringent than others? In attending to the different force of astringency, as found in different vegetables; it would appear to depend invariably on the quantity of this salt, which

the vegetable contained ; but analogy leads us to believe, and experiments inform us, that the astringency of all vegetables is varied much in proportion as this principle arrives nearer to the point of saturation, and in this manner only can we explain how the citric acid impairs the astringency of an infusion of galls ; i. e. by superaturating the earth.

Dr. Irwing, from his experiments on the Peruvian bark, was led to believe that the astringent principle was in a very fixed state, because he could not obtain it by distillation, and only by infusion: though he discovered, that it was easily destroyed by heat : but had the Doctor fortunately examined the contents of his receiver ; he would have found that the acid passed over, while the alumine remained in the retort ; which could not have failed paving the way to the true discovery of the astringent principle : particularly on observing, that the astringency is destroyed by depriving the vegetable of its acid, and again recovered by restoring it.

Thus the destructibility of astringents by heat is owing to the decomposition of the principle, which takes place on account of the volatility of the acid, which flies off, leaving the alumine behind; for there are none of the vegetable acids, which do not rise with a very moderate degree of heat; and it is on this account that decoctions of galls, Peruvian bark and many other astringents are much weaker than infusions of the same.

It may be here necessary to observe that exclusive of the gallic acid; Mr. Scheele obtained from galls, both by distillation and crystallization, a volatile salt which he took to be the true acid of galls. But although this salt has not as yet been decomposed ; it is probable nothing more than the gallic acid united with a volatile oil, forming a neutral.

Since we are thus well acquainted with the analysis of astringents, the synthesis becomes easy, and we are able to make a combination of these principles invariably serve as a substitute adequate in power to the production of nature. Some will say, that human device is never equal to the laboratory of nature, and that her imitation is beyond the sphere of our knowledge. This I deny; for in some instances, nature lights us through her labyrinth; and by varying, and multiplying her productions, invites us to imitate them. In astringents, we may go further than imitate her; for by varying the proportions of the elements, we may at pleasure regulate the dose.

Having considered, and explained, as far as it lies in my power, the constituent parts of the astringent principle. I am next to attempt the explanation of a phenomena, that takes place in mixing them with preparations of iron.

Though it has been for a long time known that an infusion of galls, and other astringent vegetables; with very few exceptions: have the property of striking a black colour with the sulphat of iron, or green vitrol; and chemists have at all ages thought their time well employed in examining a subject, which exhibits such singular phenomena; yet we find it was not until very lately, that any light has been thrown on the subject; and our most earnest endeavours to ascertain the production of ink, have fallen far short of our anxious wishes until a complete analysis of the astringent principle was discovered by some very late and ingenious experiment.\*

\* Dr. Woodhouse, in an inaugural dissertation.

For though facts have been indeed attended to ; instead of suffering them to speak for themselves experimentalists have been desirous of making applications, drawing conclusions, and establishing theories, which for the most part have been opposed by most powerful facts, Each of them have for a time gained countenance, but soon fell again into disrepute, partly from their own insufficiency, partly from the greater plausibility of others.

The doctrines on this subject have generally been drawn from mistaken facts, and an imperfect view of things ; and have often times been explained on mistaken principles.

Dr. Percival ; who appears to have paid particular attention to the formation of ink ; imagined that the presence of sulphuric acid was essentially necessary for that process to succeed. The experiments employed by the Doctor on this occasion appear very unsatisfactory, and his conclusions therefore must be erroneous. However he thought he had proved it beyond a doubt. and the happy series of experiments brought forward, for the establishment of his opinion, has generally been received as so complete that until very lately his doctrine has never been denied ; but on the contrary admitted, as founded on absolute proof. But later experiments have (as I observed) acquainted us with the true analysis of the astringent principle ; and our discoveries of this kind shew us that the doctor was necessarily led into an error for want of this knowledge.

Dr. Irwing who has wrote professedly on this subject, and made a number of very ingenious experiments seems to have thrown no more light on it, than the learned Percival ; for though his experiments were made with great accuracy ; they

were however productive of very great deception. But had the doctor confined himself to the simple relation of facts, he would have probably announced a valuable, and external truth : but when he concludes that the production of ink depends upon the presence of carbonic acid he asserts that which his experiment did not point out, and proceeded much further than facts warranted ; and it is in this manner that we frequently find the most ridiculous applications degrading the sublimest truths.

The Doctor supposes carbonic acid, necessary in the production of ink, only as being subservient to the deposition of phlogiston, a principle now nearly exploded from chemistry. In illustration of this opinion he observes that good ink is pale when first applied to paper, and in the course of drying becomes black ; but drying the writ, hastily by the fire prevents this improvement. But this appears only to prove that the galic acid is of a volatile nature, and passes off on the application of heat, leaving the iron in the form of a calx ; for the colour may be again restored, by adding the acid. It is in this manner that we must explain, both the decay of old writ, and the restoration of its legibility, by an infusion of astringent vegetables.

I know not how the doctor could have fallen into this mistake, for at the same time he adopts the opinion, he candidly acknowledges that the effects of carbonic acid on iron, does not in any manner justify the smallest suspicion of the kind.

However, I wish, by no means, to depreciate in the smallest degree, the merit of this judicious experimentalist ; for whose abilities I entertain the highest esteem : My design, being only to evince the extent of our knowledge on this subject. It would be unjust, to cast any reflections on the opi-

nion he entertains, since he only delivers it as a probable conjecture, and as it has not gained a very absolute empire, over the minds of many, I consider it unnecessary to dwell further on its refutation; particularly as my attention is chiefly directed to the consideration of the present doctrine, now so much admired as being the latest, and which is established by ingenious experiments, and supported by the strongest facts. It is that of ink, being produced by the mere combination of iron, and the gallic acid.

From the analysis of the astringent principle, we are taught that in making of ink, a decomposition must take place, by double elective attraction: For while the sulphuric acid unites with the alumine, or base of the astringent principle, the gallic acid unites with the iron, and forms ink. The alum, that is produced in this process, seems to serve as a mordant, or fixer to the ink; for we observe, an ink may be formed by the mere solution of iron in the gallic, the citric, and many other forms of the vegetable acid; though prepared in this manner it is never durable, because it wants the alum as a fixer. That this is the true theory of the production of ink, appears to me to be established on the most complete proofs, which can be desired in matters capable of demonstration.

The black colour generally produced, on the union of astringent vegetables, and green vitriol, has for a long time been made use of as a criterion to judge of the astringent quality of all vegetables; but the fallacy of this test has in so many instances been discovered; that it appears hardly necessary here to observe, it is one of the most uncertain, which can be made use of: For it is not only the gallic acid united with alumine, forming the a-



stringent principle, that will strike a black colour, with green vitriol ; but the vegetable acid in most of its modifications will produce the same effect. Thus the citric, or gallic acid, when united with alumine, chalk, or any earth, from which they may be disengaged, by the sulphuric acid ; will, upon being added to a solution of green vitriol, seize on the iron, and precipitate it black.

It is in this manner that we must explain, how vegetables, which possess properties very different from astringents, exhibit the same phenomena, upon being mixed with preparations of iron ; viz. by supposing the vegetable contained the acid, united with some other body than alumine, from which being disengaged by the sulphuric, it unites with the iron.

Thus I apprehend, that astringent vegetables like most other productions of nature, are only to be known, and distinguished by their sensible qualities ; and of course the taste must be the most unexceptionable criterion to judge of their power ; and it appears to be a certain assemblage of principles, which gives the vegetable astringent its sensible form.

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## OPERATION OF VEGETABLE ASTRINGENTS.

Man no doubt in the earliest ages of society was afflicted with disease, and the great Creator of the universe seems to have distributed over the face of our globe, in its first formation, remedies for all the evils, to which its Inhabitants are exposed ;

for we find man no sooner felt pain, than he found relief in the productions of the earth, to which he had been either kindly directed by the instinctive wisdom of nature, or driven by the violence of disease. Thus no country has been discovered, in which the people have not been acquainted with a number of remedies, and in which medicine had not been in an improved state, before any other art had taken root: and that indulgent Being, who first formed the mind of man capable of improvement, and appointed no bounds to his acquisition of knowledge, has at the same time planted in his breast a degree of curiosity, which stimulates him to an inquiry into the most hidden *secrets* of nature. Thus man appears no sooner to have discovered a remedy for his disease, than to have been naturally led to inquire into its mode of operating; and an explanation of the phenomena, which takes place in the use of astringents, appears at an early period of medicine to have been a favourite object of the human mind. But were we to judge from the tardiness of our progress here, it would appear that nature had some private views in keeping us in darkness.

But this is not the case, and the capital errors, which have prevailed at different periods, in the Philosophy of the operation of medicine, appear to have arisen from an absurdity, which is prevalent even in modern times, that of finding out and explaining by the chemical analysis of substances, the changes produced in our bodies by them. Some observing the various substances of the universe might be traced to a few ultimate principles between which there appears an intimate relation, were led to imagine that the source of activity of all bodies, and their effects upon the system might

be explained from a knowledge of their constituent parts ; but unfortunately for the science of chemistry it has but little to boast in any improvements of this kind.

We have turned our attention entirely to the chemical properties of medicine, while we have lost sight of the animal economy, or been ignorant of its operations ; for though physiologists have for a long time attempted to explain the animal operations, and show how they may be influenced by external agents, yet their opinions, as being the inference of fallible reason, have at all times been subject to the greatest mistakes ; and I doubt not if physiologists had spent that time, in making accurate observations on animals themselves, which appears to have been thrown away in mechanical, and chemical visions ; by this time we might have understood the operation of medicines much better than we now do.

However I would by no means condemn chemical analysis, but rather justify inquiries of the kind ; and a knowledge of the composition of the astringent principle seems to lead particularly to a thorough investigation of its operation.

But though we may I apprehend sometimes even pronounce, that the nature of a medicine is by analysis ; yet I have the authority of men of the greatest judgement for maintaining, that a knowledge of the operation of medicines depends much on our knowledge of the animal economy. It appears to be the only proper train of investigation ; and is to be hoped, that physicians will daily see the necessity of entering more and more into this inquiry : for it is only those men, who deliver themselves up more to observing, and studying the phenomena of the animal economy, when struggling

under disease, when in health, and even whilst under the operation of medicines, that can expect to make rapid strides in acquiring this knowledge; and those alone who have supplied us with the most valuable acquisitions,

When we come to consider the satisfaction of the mind; which arises from contemplating the fabric of man, and the influence it must naturally have over us as philosophers; we cannot fail being astonished to behold the manner in which it has been neglected, until very late; and the more we know of it, the more we are led to believe that if our senses were more acute our judgment more enlarged, we should be able to trace many springs of life, which are now hidden from our view, and by the same sagacity should we discover, not only the true cause, and nature of diseases, but should be likewise able to explain the manner in which remedies produce their effects.

There is no one, who has attended seriously to the operation of astringents, without being at the same time aware of the necessity of establishing divisions of them, in order to facilitate the study, and remove the insurmountable difficulties, which would otherwise, oppose its progress. For this purpose, they have divided them into fossil, and vegetable astringents; and though it is only the latter, to which I mean to confine myself; it may be necessary here to observe, that the former consists of earths, and acids; and neutral salts, formed by a combination of these two principles, or acids with metals. In what manner astringents produce their effects on the solid parts of animal bodies, is (as I have observed) by no means evident. When the substances applied are of such a nature, as to coagulate or absorb the fluids of the body; we can very readily understand the man-

ner in which they should condense and contract the solids. But it is the operation of vegetable astringents, which appears to have most perplexed physicians; and it is a subject which to me appears particularly difficult; because others who have treated it, have considered it, as so obscure and mysterious, as hardly to be attempted, and perhaps given over the pursuit as being beyond the sphere of our knowledge; and in what has been said on the subject, I find nothing to relieve the difficulty of the task. They have had ample latitude to display the fertility of their imagination; because Hypothesis here, however extravagant, is not easily refuted; and their opinions concerning the operation of vegetable astringents have been equal in variety to their supposed composition. Some have advanced theories, fraught with absurdities, so glaring, as to reflect their own refutation, while others, who have been men of more liberal inquiry, puzzled with appearances seemingly contradictory, have willingly called it a specific operation; which only implies a suspension of opinion on the subject, leaving it to the future examination of posterity.

An opinion, which has been pretty generally received, but I think with very little more plausibility than many others, is that offered by Dr. Cullen, who refers their effects to an attraction taking place between the astringent principle, and the particles of the animal solids: This opinion however, can by no means be held as just, for were we to admit that such an attraction does take place, we should be equally as much at a loss to explain the manner in which it produces a condensation of the simple solids, and an increase of tone in the moving fibres. I believe the chief reason, the doctor had for assigning it to an attraction, was

that no other satisfactory explanation could be given, before analysis had taught us the component parts of the astringent principle. This opinion of the doctors, appears to have been very generally received, and if those, who adopted it, had also, cultivated the same industrious plan of observation with him, or a degree of freedom in their opinions, no doubt but by this time the operation of astringents would have been more thoroughly investigated: But many have trusted more to his theory than their own observations, and even more than he has done himself; and that caution, which will even characterize him, and do honour to his memory, has degenerated in others to superstition, and timidity.

Whether I shall be able to correct, and improve the doctrine, I dare not determine; but I consider it incumbent on me to obviate a conclusion, which I do not admit of; and must therefore attempt a very difficult problem, in attempting an explanation of the manner in which astringents produce their effects. To form an accurate idea of vegetable astringents, it is necessary to take a survey of the operation of their constituent parts seperately, and account for their effects from the activity of the ultimate principles, to which they may be reduced.

Nature, as I observed, has formed the astringent principle of vegetables, by a combination of their acid, and alumine, or the earth of alum; and if we direct our attention to astringent vegetables, I believe we shall immediately find, that some of them contain a greater portion of this salt than others, and that in some instances the acid prevails, while in others the earth predominates. Therefore as I have above remarked, their astringency is varied

not only in proportion to the quantity of the salt, they contain, but likewise as it arrives nearer to the point of saturation.

Observing then that it is an acid, and an earth which give activity to the astringent principle and their separate effects on the body being that of coagulating, and observing the fluids, it is hoped that its operation may be easily explained, as depending upon the united exertion of both principles, and it appears that not only the vegetable, but likewise some of the fossil astringents, as alum &c. exert a twofold operation, that of coagulating and absorbing the animal fluids, which render them much more powerful than either of the principles separately. I doubt not that this explanation of the operation of the astringent salt, as deduced from a union of its principles, will not only appear satisfactory, in accounting for, the phenomena which take place, but when extended to observation, will more fully evince the justness of the doctrine.

However there may be an objection offered to this opinion, which is that compound bodies do not partake of the properties of their principles, and though the general facts in chemistry teach us, that a neutral union of bodies seldom fails to diminish the power of each principle. Yet astringent salts appear to be an exception this rule for we observe they differ in their effects on the body from their principles only in producing them in a greater degree.

But from the violent contraction which takes place in the solids, on the application of astringents, particularly of the vegetable kind, it would appear that some other power was exerted exclusive of absorbing and coagulating the fluids. However I must observe there appears to be a force of mu-

tual attraction between the solid part of animal bodies; and this principle alone is sufficient to produce that force of cohesion of the particles of the solids, on the abstraction of the fluids, the circulation of which through the body, appear to be the principal agent employed by nature, incessantly to destroy the adhesion of the particles of the solids; and there is undoubtedly, as well in animate, as inanimate bodies a primordial law which tends to bring together their particles, and at the same time a powerful agent which removes them from each other.

From all this, it appears obvious that it is especially from the contractility of the simple solids, that their density arises on the abstraction of the fluids. There are many other considerations, which support the opinion of astringents acting solely on the simple solids; but the most striking are the similarity of their action on the dead, and living fibre, their effects always first appearing on the simple solids, and from thence communicated to the moving fibres, and their effects never appearing in the vital functions, so as to increase in the smallest degree their action; though they appear in the natural functions, particular in diminishing, and suspending many of the secretions, and exertions.

After this view, of the operation of astringents, it may be necessary to remark, that though they act first, and especially on the simple solids, their effects are very generally communicated to the moving fibres; from whence there is a considerable difficulty occurring, for although they diminish the sensibility, and irritability of the system, instead of proving sedative rather increase the force of action, and therefore often prove powerful tonics. An explanation of this appears difficult, but I would



have it observed, that the astringents, which exert a tonic power are chiefly of the vegetable kind, and at the same time discover a considerable degree of bitterness. Now as the tonic power of vegetables, is the same quality which gives them their bitter taste, it appears clearly that many vegetables possess a tonic, as well as an astringent matter, therefore their tonic effects are generally in proportion to their bitter taste and not to the astringent power.

However it has been observed, and I believe with some degree of propriety, that other astringents than vegetables, for instance as alum exert a tonic power. How this can be explained, in consistency with the opinion I have advanced, may appear difficult; but we must refer it to the change induced in the simple solid increasing its density, and firmness. For it must be observed, that as a difference in the state of the simple solid, always occasions a change in the moving fibre, so it must be admitted that the state of the latter, is considerably modified by that of the former, and we find that the simple solid, according to its density has a great share in determining the strength of the moving fibre. It further merits particular notice, that any incidental, and sudden Change in the solids producing an increase of their density, the force of the moving fibres is increased; therefore it does not appear to be from any direct operation on the moving fibres, that their tone is increased; but from the change induced in the simple solids: and from this it appears obvious, that it is especially from the operation of astringents on the simple solids communicated to the moving fibres, that general effects, so readily appear over the whole system.

I have no doubt that what I have said upon the operation of astringents may in some manner be liable to the imputation of conjectural reasoning; but I vain hope that it may in some manner lay the foundation of speculation, which must be pursued, before we can explain the important and therefore necessary doctrine of their operation, and what I have delivered I must offer only as a probable hypothesis, which awaits the confirmation of future observation.

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### IDENTITY OF THE VEGETABLE ACIDS.

ACIDS possess a more extensive power of acting upon other matters than perhaps any other bodies we are acquainted with; and have therefore been successfully, and extensively employed as chymical agents to develop the constituents parts, and investigate the properties of other bodies. They are to be considered as bodies of a singular nature; whether we view their origin and formation, or their peculiar properties and uses, as being the most active instruments in chemistry.

It was the opinion of Stahl, and many since his time, that vegetable acids were much weaker than any others; and this idea has been strenuously adhered to, until it was discovered that the oxalic acid seized lime from the sulphuric.

It appears now beyond a doubt that vegetable acids, like all others are combinations of oxygen or the base of vital air with a certain elementary principle. The contemplation of such an active agent, as oxygen, has greatly enlarged our knowledge of chemistry and taught us, that acids, to

which we have been lavishly attached, as principal agents in chemistry are compound bodies. The analysis of all those acids, whose component parts are known, establishes the truth of oxygen being the acidifying principle, and it may be given in a positive manner as a truth of fact, and observation, and looked upon as a constant law of nature: for though we have not as yet been able to decompose the vegetable acid; we are at least convinced that oxygen, is a principle common to all its varieties; and necessary to their formation, and in fact, it has been proved, by the most accurate experiments, that oxalic acid cannot be obtained from sugar except a portion of oxygen be united with some principle of the sugar, and in this manner likewise, is the acetous acid produced in fermentation.

Vegetable acids have hitherto been considered as differing in species, when obtained from the same vegetable by different means and some chemists, by considering no acids identical, but such as form exactly the same salt, with the same base, have multiplied the acid, obtained from vegetables to infinity: And in this manner the various degrees of saturation of the same principle with oxygen, have established various kinds of acid.

The acid, which is obtained from vegetables, may be considered in two points of view, either as it exists in the vegetable ready formed, or as the vegetable contains the radical principle of the acid only, and the reagent, with which it is treated, affords the oxygen; which we find to be the case in the production of vinegar. Here we find the acid extracted, which did not exist in nature: for there are many vegetables which give no traces of acidity in distillation; from whence we may rea-

sonably infer, they contain none, yet by fermentation they yield a considerable quantity, which shews that the acid base, existed in the vegetable, and only required the presence of pure air, to produce the acid.

We find, that vegetables at different periods of their growth, contain very different portions of acid. In explanation of this, it is necessary to observe, that they constantly absorb atmospheric air, of which they retain the nitrogyngas, and extrude much of the oxygen, or pure air. A portion of oxygen, which they retain uniting with the radical, in different proportions, form all that variety of acid, which we obtain from vegetables. At first the pure air being in great proportion, gives a considerable degree of acidity, but as the leaves expand themselves, and present a greater surface to the action of light, the oxygen, is more copiously expelled, and the acid being by that means destroyed, the plant acquires a saccharine quality; and thus in vegetation, we find perpetual changes taking place, in the proportion of the elements, and new combinations. Though vegetables are not like minerals modified by external causes, but being in a manner animated, and governed by an internal force, possess characters of a more definite, and unchangable nature; and though the proceedings of nature respecting them are more constant, and better ascertained: yet they are in a great measure obedient to the laws of attraction: And we may, I think, refer most all the phenomena of decomposition, and formation of which vegetables are susceptible; to the mere law of affinity, and this no doubt is the cause of that innumerable variety of forms, under which the vegetable acid appears, and which scarcely permit the chemist to establish a system of them, on a fixed basis, or

found it upon constant, and invariable characters.

While we trace with wonder the variety of productions of nature in the vegetable kingdom, we cannot but admire the beautiful order, she every where observes. The acid obtained from different vegetables by the same process resembled each other in all its sensible qualities, and chemical properties: for we find vinegar produced by fermentation from most every vegetable; and on the other hand we observe the results of the same plants as treated in a different manner, vary considerably; thus for instance, how different are the sensible qualities of the acid as obtained from the same vegetable by distillation and fermentation though the former may be always converted into the latter.

Though the minds of chemists have been for a long time bent on the identity of vegetable acids; and some at a very early period ventured to hazard a conjecture that their great variety were nothing more than different modifications proceeding from different proportions of the same principles; yet it was not until very lately, that any experiments were made which establish this opinion.

No chemical difference has hitherto been discovered to exist between these acids, and no principle or product has been obtained from one of these divisions, which may not likewise be drawn from all the rest; nor can any other distinction be shown, than what may proceed from a difference in the proportion of the component parts; which difference subsists between every other vegetable matter, and it seems consistent, with distinctness of representation, to consider in one view all acids that are obtained from vegetables under the general head of acetic acid, or radical vinegar.

1<sup>st</sup>. Mr. Scheele observes that though the exalic acid expels vinegar from the fixed vegetable alkali; yet it is destined to become vinegar itself and is easily converted into it.

2<sup>d</sup>. Either the tartareous, the gallic, or the citric acid, when treated with the nitric acid in the manner commonly practiced in the preparation of the axali, may be changed into the latter, and this may be further converted into acetous by the same process.

3<sup>d</sup>. Gum arabic treated with the nitric acid yields the exalic, and sometimes the malic.

4<sup>th</sup>. by boiling one part of the exalic acid with one, and a half of manganese, and a sufficient quantity of nitric; the manganese is dissolved, and vinegar with nitrous acid pass into the retort.

5<sup>th</sup>. By boiling tartarous acid, and manganese with the sulphuric acid, the manganese is dissolved and vinegar with sulphuric acid are obtained.

6<sup>thly</sup>. By digesting either the citric, the exalic, the malic, the lactic, or the tartareous acid for some Months with alcohol the whole is converted into vinegar.

These experiments are clear, and the proofs, we draw from them seem conclusive: and in the strongest manner confirm the existence of only one principle as the common acidifying base of vegetables; and the specific difference of these acids depends not on any essential difference of their acid parts; and probably not generally on any adventitious substances with which these acid parts may be combined; tho' that may give some different modification to the acid; but rather on the different proportions of their constituent parts.

The citric, the exalic, the gallic and all the other acids, may be considered as nothing more than the

acetic deprived of part of its oxygen; and the acetic differs from all the rest only in containing a great portion of oxygen. Thus for instance if the saturation be not exact the result will be the axalic, the citric, or some other acid; but if either of these be treated with the nitric, the latter will be decomposed and vinegar will be formed, which is capable of being combined with a still larger quantity of oxygen, and then forms the acetic acid.

Mr. Hermstadt attempts to prove that tartareous acid is the true vegetable acid; of which the acetic the axalic, and others are only modifications. But although the easy conversion of the tartareous, the axalic and all the rest into the acetous and that into the acetic, shows that they all contain one principle, I see no reason, why the tartareous should be considered as the fundamental acid. But if we were to fix on one as the primitive acid of the vegetable kingdom it should be the acetic, as being the most perfectly acidified, and the one into which all the rest are changed by the addition of oxygen: and though all the rest may be converted into the acetic, there is not an instance of any conversion in the contrary order, that is of the acetic into the acetous; or the exalic into the acid of tartar, or any other except the acetous.

We observe, that the imperfect acid may be converted into the more perfect, by other means than the nitric; for Stahl found, that lemon juice, when saturated with an absorbent earth, and preserved with the addition of spirit of wine, acquires the properties of vinegar. But this can be accounted for only on the same principle, on which we explain the conversion of this acid into vinegar by means of the nitric, that is by supposing that the spirit affords the citric a portion of oxygen, which is always necessary for its conversion.

From the frequent appearance of the same kind of acid in many different vegetables and from their easy conversion into each other; it appears to be established beyond a doubt, that vegetable acids contain some common principle, which may be considered as the general acid base, and that upon this by certain additions or subtractions either of its own elements, by which their properties are changed, or of other adventitious matters; the characteristic difference of each species depend.

But what this principle is, appears difficult to say; and however interesting an enquiry into the component parts of vegetable acids may be: our knowledge of their chemical analysis is not yet sufficiently extended, and confirmed to enable us to investigate them with precision. Nevertheless in a subject of great obscurity, it may be allowed to make the best use we can of the facts we possess, and some latitude may even be given for conjectures provided they be represented as such.

Mr. Keir imagined that the acetous acid is composed of spirit of wine and oxygen: but Mr. Chaptal discovered, from experiments made by himself, that a mucilaginous principle was more especially the substance on which the acetous fermentation depends, and he observed that when this principle had been destroyed, as in old wines, they were incapable of advancing to the acetous fermentation, without the addition of some gummy matter: and we find that all kinds of spirit, when deprived of mucilaginous matter by distillation, are incapable of proceeding to the acetous fermentation. Therefore the acetous fermentation must evidently depend on the mucilage of vegetables, and not on spirit. It was moreover for a long time supposed that spirit was necessary to the production of vine-



gar ; but Mr. Scheele has of late formed it by decomposing the nitric acid on mucilage.

As acids may be obtained by some means from almost every vegetable, it must be admitted that they are essential principles in the constitution of them, or at least if the acid is not, its basis is, and only requires the addition of oxygen to form the acid : which we find to be the case in the acetous fermentation, and evidently takes place in the production of the oxalic acid. But in the production of this acid, I do not suppose that the sugar in the acidifying principle, as Mr. Lavoisier has done : for it has been discovered, that this acid improperly called the acid of sugar, may be obtained from numberless substances which contain no sugar. Therefore the sugar employed cannot be considered as the radical, but merely as containing it, and which I take to be a mucous, that is always contained in sugar, and which consequently must be an element or constituent part common to all the various substances from which this acid can be obtained.

Mr. Morveau thinks that this common principle, or acidifiable basis, is an attenuated oil : but were this the case, we would find that the quantity of acid produced to be in proportion to the oil contained in the substance made use of. But we find the reverse takes place, and vegetables which contain a large portion of mucous, produce a larger quantity of acid than those which contain oil. Thus, for instance, the farinaceous seeds more readily advance to the acetous fermentation and yield a greater quantity of acid than the oleaginous do.

That the mucous is the radical principle of the vegetable acid, and pervades the whole of the vegetable kingdom appears in a stronger point of view, from observing that the acetous and tartar-

ous acids are subject to a peculiar kind of spontaneous decomposition, in which there is separated a considerable quantity of mucous matter, and when this takes place, the acid is entirely destroyed, or at least considerably impaired in its strength which undoubtedly is owing to the separation of its basis.

The truth of this opinion appears more apparent from another leading fact; that of Mr. Scheele's not being able to convert the chrysalized acid of lemons into the oxalic, by means of the nitrous, though he accomplished this by treating it with a mucous; which proves that the citric, when in a chrysalized state, is much higher oxygenated than the oxalic. Therefore it is by increasing the acidifiable basis, that we can convert the former into the latter.

These reflections seem to make it a reasonable inference, that all the vegetable acids are composed of two principles viz. oxygen and mucous; which being united in determinate portion forms the citric, with a larger portion the oxalic, and with a still larger portion the acetous, which is capable of combining with a larger quantity of oxygen, and then forms radical vinegar, or the acetic acid; or at least, if the mucous be not itself the base, it contains it, which is of such a nature, as not to be obtained in an uncombined state, and only separates from one body, to unite with another, and must therefore forever elude our researches.

It has been a general opinion among those concerned in experiments on acids; that the vegetable acid differs particularly from those obtained from animal substances. However as the oxalic acid has been obtained from a variety of animal substances, as well as vegetables, and as this acid is converted into the acetous, merely by

increasing its oxygen, we have no reason to suppose that the acids of vegetable and animal substances are capable of any chemical distinction, and I believe if we were to consider them as relative to their properties especially their analogies and parts into which they may be resolved, we should find no essential difference in them. Moreover it has been discovered that the phosphoric and sebatic acids, which have hitherto been considered as confined entirely to the animal kingdom, may be likewise obtained from many vegetables. From observing the great similarity of the properties of particular acids procured from animal matters with those of a vegetable origin we are led to believe that notwithstanding their immediate source; some of them, particularly the sebatic acid, may be considered as proceeding from the vegetable matters of the food, passing unassimilated by the animal economy; and it is further probable that all the animal acids which we have not as yet been able to decompose, with sufficient accuracy to know their constituent principles have the same base with the vegetable acids, and owe their acid properties to oxygen; and it appears that the differences presented by these acids, depend, as that of the vegetables do, on different proportions of the acidifiable base and oxygen; and the proportion of the acidifiable base and oxygen vary in each of these acids.

The effects of vegetable food, on animals clearly follow from some qualities peculiar to them as vegetables; and these qualities seem to be the power of generating an acid which is afterwards found in the body; and we find that the quantity of acid in animal bodies is much regulated by the vegetable food taken in. It is a fact well known, that acids

when combined with oils give them firmness and solidity; thus the fat of herbaceous animals is an oil in a concrete form, which by distillation yields a phlegm that is highly acid, and if this acid be entirely dissipated by repeated distillations; the dense facts become fluid oils; and by Mr. Macquer's chemical analysis of fats we are informed, that not the smallest portion of volatile alkali can be obtained from the fat of the herbaceous animals. We find from a deficiency of this acid in the fat of carnivorous animals their oily parts are more fluid than those of herbaceous; and when there is a strong putrescent tendency in the body, the fat is more fluid for want of this acid, which defect is removed by taking in a large quantity of vegetable acid, or even of vegetable food whereby an acid may be generated.

We may moreover by the different degrees of density of the fat of herbaceous and carnivorous animals perceive the gradual extinction of acid through those different stages in proportion as they become more removed from the vegetable kingdom.

There is I apprehend every reason to believe, that most of the acids obtained from animal matter, owe their origin indirectly to the vegetable kingdom, and though we are far from a knowledge requisite to give a complete theory of their formation: yet from the palpable state in which they are found; from observing the manner in which they are influenced by vegetable food, and the coincidence of properties, which exists between them and vegetable acids; it appears to be proved, beyond a doubt that the transition to acid is actually performed in the stomach, and can only differ from the vegetable acid as being united with some adventitious

substance, or differently modified by the different processes it may undergo in the animal.

It may be here proper to observe that this theory of the identity of the vegetable acids is so far from interfering with the growth and power of assimilation of vegetables, that it rather serves as a clue to their similarity ; and in their productions we find nature more identified than in any other of her operations. We find in different vegetables a saccharrine matter, and who would pretend to say it is differently formed : and upon the whole I do not doubt, but that an accurate attention to the intimate connection existing between the productions of different vegetables will show the real statement of facts, and establish the theory laid down.

*F I N I S.*

