Senpaja Rajat. 1830

A

GENERAL SYSTEM

OF

CHEMICAL KNOWLEDGE;

AND ITS

APPLICATION

TO THE

PHENOMENA OF NATURE AND ART.

BY A. F. FOURCROY,

Of the National Institute of France, Counsellor of State, Professor of Chemistry at various Public Establishments, Member of many Academies, &c.

IN ELEVEN VOLUMES.

TOGETHER WITH A SET OF SYNOPTIC TABLES IN LARGE FOLIO.

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A

SYSTEM

OF

CHEMICAL KNOWLEDGE.

SEVENTH SECTION.

Of the Vegetable Organic Compounds.

INTRODUCTION TO THIS SECTION.

1. I HAVE hitherto treated of ſubſtances, all which belong, by reaſon of their ſimplicity or their little complicated compoſition, to the bodies which naturaliſts place in what they term the *mineral kingdom*, and which, as they compoſe the ſolid maſs of the globe, deſerve more accurately the name of foſſils. The ſubſtances whoſe hiſtory I am about to write, and which conſtitute the ſection I now commence, are of a very different nature: much more complicated than the preceding, the vegetable ſubſtances not only form a very diſtinct order of bodies, but they alſo require to be examined, and treated according to a very different method. The courſe of the ſcience ought here to differ as

well as that of nature; and inſtead of dividing this ſection, like the preceding ones, into articles placed ſucceſſively, one after the other, and placed as the neceſſary and continued ſeries of truths connected immediately with each other, the facts and the phenomena are here too complicated, and hitherto too little as yet approached to each other, and too little dependant, for it to be poſſible that I ſhould preſent them, like thoſe of the preceding ſections, in a continued and uninterrupted ſeries of articles.

2. I am therefore obliged to divide all that I have to ſay relative to the vegetable compounds into ſix orders of facts, which comprehend all the knowledge hitherto acquired, and even the ideas of what is ſtill to be acquired, reſpecting the nature, the formation, the difference, and the alterations of theſe compounds. For it is here to be remarked, that vegetable bodies are divided and ſeparated from the mineral ſubſtances by a great difference with relation to the chemical parts which compoſe them. Organic compounds in general, and thoſe which belong to the vegetables in particular, are ſtill much leſs known than the mineral ſubſtances; and though, as we ſhall ſoon ſee, modern chemiſtry has ſingularly advanced the vegetable analyſis, it has rather, as yet, acquired hopes and produced writings, than collected general reſults. The great point in the ſtudy of this beautiful department of ſcience is, to familiarize ourſelves with the well-eſta-

bliſhed

bliſhed and poſitive notions already in our poſſeſſion,—to acquire at the ſame time a clear underſtanding of what ſtill remains defective,—to comprehend well the means of acquiring what it wants,—to appreciate rightly the truth of the ſpeculative views to which it has raiſed itſelf,—and to become able, by means of thoſe valuable inſtruments which we begin to know how to employ, to advance this very intereſting branch of natural philoſophy.

3. The ſix orders of facts into which I divide, and under which I comprehend all that belongs at preſent to vegetable Chemiſtry, are reducible under the following heads:

The firſt relates to the ſtructure of vegetables, and the difference of this ſtructure from the texture or the maſſes of mineral ſubſtances. It would be impoſſible to form a conception of their chemical properties, if we had not an exact though preciſe notion of their organization, or the firſt cauſe of the differences which diſtinguiſh them from inorganic ſubſtances.

In the ſecond order of facts, I include what relates to the vegetable nature or compoſition in general: this is a neceſſary conſequence of their organization, which admits of a kind of combination very different from that of the minerals; and it is neceſſary firſt to know in what this difference conſiſts.

To the third order belongs the kind of action which the principal ſubſtances already examined exert upon vegetables; that is to ſay, the chemical characters which they prefent, by means of which we difcover their nature, and determine their compofition.

The fourth order of facts comprehends the examination of all the fubftances which are extracted from vegetables, which really conftitute them, and which on that account are called the *principles* or *immediate materials* of vegetables. This is the longeft, and requires the moft details, becaufe it is the moft abundant in facts, upon which the moft labour has been beftowed, and has hitherto folely conftituted the vegetable analyfis.

In the fifth order I rank the expofition and ftudy of the different natural alterations to which vegetables are liable, and which, being dependant upon their compofition, are at the fame time very proper for acquainting us with its nature.

Laftly, to the fixth order of facts I refer what I term the phenomena of vegetable life, or the application of all the facts preliminarily explained in the preceding orders, to the vegetable phyfics. This laft, which is the complement of all the reft, the object to which they manifeftly lead, is one of the moft beautiful refults of modern chemiftry.

First Order of Facts relative to the Vegetable Compounds.

Concerning the Structure of Vegetables, and the Physical Differences which distinguish them from inorganic Bodies.

Article I.

Of the external or apparent Structure of Vegetables.

1. The first observations which man, placed upon this earth, could make upon the productions of nature around him, must have showed him that vegetables differed in a remarkable manner from the substances which form the mass of the globe in their appearance, stature, aspect, and all the properties which quickly characterized them to his eyes. When he wished to account for the difference that had struck him, he could not fail to remark in particular the variety and the dissimilarity of their parts, and the diversity of form in the different points of their surface; whilst the stone, the pebble, the mineral and the fossil, of whatever nature they might be, presented to him a perfectly uniform whole, a mass homogeneous throughout all its continuity.

2. When we wish to define a vegetable, we are obliged to consider it as a compound of different dissimilar parts, which are designated by the names of *root, stalk, leaves, flowers, fruits,* and *seeds.* The vegetable which presents all these

theſe parts, developed ſucceſſively and at different periods of its life, is called a *perfect vegetable*. Thoſe in which ſome of theſe parts are wanting are termed *imperfect*. There are ſome plants which ſeem to be nothing elſe than roots, ſuch as the truffles, and others which want them, as the lichens, &c. There are ſome which have no leaves, and ſeem to conſiſt merely of ſtalks and branches, whilſt others have only leaves without ſtalks: ſome preſent very diſtinct and eaſily recognizable flowers; others preſent no organs that can be conſidered as flowers, though there are, in fact, no vegetables that are really deſtitute of them. In the one, we eaſily obſerve the fruits and the ſeeds; in the others we find no parts that reſemble them. However, the number of vegetables which contain all theſe parts is ſo conſiderable, and they appear to be ſo conſtant, and ſo deeply connected with the nature of vegetable, that we are induced to believe that even thoſe which ſeem to be totally deprived of them, preſent, when attentively examined, parts which might be conſidered as real flowers or fruits neceſſary to the re-production and the propagation of the ſpecies.

2. The root, which is moſt frequently buried in the ground, ſometimes immerſed in the water, or penetrating the texture of various other vegetables, ſupports the whole plant; it takes up and conducts into the vegetable a large portion of its nouriſhment, by the fibrils which are

are termed capillary, and which may be considered as absorbent vessels, as mouths destined to suck in the juices of the earth and of the manures. Botanists distinguish roots according to their form, texture, and situation, into the tuberous, the bulbous, the fibrose, the contorted, the repent, the horizontal, the oblique, the rounded, the irregular, the conical, the cylindrical, the fusiform, the articulated, the palmated, the fleshy, the woody, &c. &c. These differences have even been frequently employed by them to serve as characters of different species.

4. The stem which proceeds immediately from the root, with which it appears to be continuous, though it is of a very different structure, is the general support of all the parts: it is termed *trunk*, when it is bulky and solid; culm or straw, when it is hollow; stalk, when it supports a flower: it is round, square, triangular, smooth, viscous, canulated, straight, inclined, bent, articulated, pithy, &c. it is divided into branches, and these into boughs. The trunk of a tree is distinguished into wood and bark; the wood into ligneous substance and alburnum or sap; the bark into Epidermis and cortical layers. Botanists make use of the remarkable differences of this part in order to describe and characterize vegetables. According to this they distinguish trees, shrubs, the woody plants, the herbaceous plants, the gramineous plants, the reeds, the rushes, &c. &c. it affords many characters, species, and varieties. It is also, in this part, the general

general fupport of all the reft, that we beft perceive the internal ftructure, the real anatomical texture of vegetables, and that we obferve the principal phenomena of their organization and functions, as I fhall fhow in the following article.

5. The leaves, a kind of flat tiffues, which feem to be laminated branches, compofed of the fame internal parts as the ftalk, the ornament and verdant clothing of the vegetable, organs deftined to entertain by their multiplied furface immenfe communications with the atmofphere, conftitute the parts which differ the moft from each other, and which furnifh at the fame time the greateft number of notions to be acquired, and the greateft part of the defcriptive characters which botanifts can employ in order to diftinguifh the feveral fpecies. The leaves differ:

a. With refpect to fize; fome are of an enormous extent; others are fo fmall that they are fcarcely difcernible.

b. With refpect to form: they are oval, round, linear, elliptic, triangular, fquare, tetrahedral, hexahedral, oblong, femi-lunar, pointed, truncated, lanceolated, fagittary, cuneiform, lyre-fhaped, cylindrical, in the form of prifms, &c.

c. With refpect to their contours or their margins, they are even, dentated, channeled, angular, undulated, truncated, laciniated, fmooth, wrinkled, circled, edged with various colours, &c.

d. With refpect to their appendages; they are naked,

naked, armed, brifly, thorny, hairy, downy, aculeated, hamous, rugous, granulous, glandulous, tuberculous, &c.

e. With refpect to their furfaces, or the upper and the lower fide: they are fmooth, polifhed, varnifhed, brilliant, dull, even, unequal, finuous, perforated, porous, with holes, flat, convex, concave, caniculated, in the form of a cup, curved, &c.

f. With refpect to colour: light-green, dark-green, red, fpotted with veins, clouded, of a fingle colour, verficolor, painted, diverfified, efpecially in their two furfaces, &c.

g With refpect to their fimplicity or compofition: they are fimple or three-fold, four-fold, lobous, &c. The compound leaves have leaflets arranged oppofite to each other, when they are termed oppofite, or without being oppofite to each other, when they are alternate; either with or without an odd leaflet, which terminates them: they are called palmated, pinnated, bipinnated, tripinnated, according to the order of their compofition.

h. With refpect to the manner in which they are attached to the ftalk; they are feffile, petiolated, oppofite, alternate, verticillated, amplexicaulate, perfoliated, vaginated, &c.

i. With refpect to the fituation which they occupy in the plant; they are radical, caulinary, floral, axillary.

k. With refpect to their confiftence; they are

 foft,

ſoft, dry, papyraceous, ſilky, thick, fleſhy, fat, or coriaceous.

l. With reſpect to their taſte and ſmell: they are herbaceous, inſipid, ſweet, ſaccharine, auſtere, acid, bitter, aſtringent, acrid, cauſtic, burning, inodorous, aromatic, fragrant, ambroſiacal, fetid, virous, alliaceous, reſembling ſome known odours, vulvary, ſtercoraceous, urinous, having the ſmell of roaſted fleſh, &c.

The ſupports which bear and attach them, or the petiolæs, which are continuous with the ſtalk or the branches, containing in contiguity with each other the veſſels which ſpread themſelves between their two ſurfaces, vary alſo greatly in their length, their thickneſs, their form, their colour, their nakedneſs, their defences, &c.

6. The flowers, precious organs, the maſter-piece of the vegetable creation, the nuptial-bed which incloſe and conceal the connubial rites of the plants, are compoſed of parts which defend the organs of generation, and of theſe organs themſelves. When they contain both the external coverings and two ſexes, they are termed *complete* and *hermaphrodite*; when they are deprived of ſome, they are ſaid to be incomplete, male, female, with fruits, &c. The external parts, a kind of integuments, which defend or ſupport the internal, are the calix, the receptacle, the corolla, and the nectary; the internal parts, the genital organs, are the ſtamens and the piſtil.

A. The

A. The calix, the outermoſt and the thickeſt tegument, a continuity of the bark, the green colour and texture of which it generally poſſeſſes, is called the *Perianth* in moſt of the flowers, which it ſurrounds like a vaſe; *ſpathe*, in the liliaceous plants, in which it quits the flowers which raiſe themſelves above it, dries, drops off, or diſappears; *chaff* or *glume* in the gramineous, in which it has the form of a ſimple ſcale; *involucre* in the umbelliferous, in which it connects and incloſes the parcels of flowers by its lineary and filamentous diviſions; *catkin*, or a falſe calix; a conical or cylindrical ſupport of a great number of monoecial or dioecial flowers; veil in the moſſes; hood in the muſhrooms. The calix is uniflorous or multiflorous, partial or common, hard, ſoft, permanent or deciduous, drying or ſwelling, in order to become the fruit, extremely varied in its form, its ſize, and all its properties; it is rounded, globular, cylindrical, dentated, divided, monophyllous, polyphyllous, ſimple, double, triple, ſmooth, canulated, ſpinous, hairy, glandulous, open, dilated, cloſed, contracted, &c. Rivinus, and ſeveral other botaniſts, have founded a method, or regular claſſification of vegetables, upon the ſtructure of the calixes.

B. The receptacle, a ſort of plate that terminates the ſtalk, of which it is commonly nothing elſe than the extremity dilated into a button, forming ſometimes a diſtinct and enlarged fleſhy

maſs,

maſs, ſupports all the parts of the flower; the calix which forms its external circle, the border, and frequently envelope the corolla in a ſecond circle, the ſtamens in a third, when they are attached to the receptacle, the piſtil in the centre. Sometimes the receptacle ſupports the ſeeds uncovered after the flower; ſometimes it ſerves as a covering for it, and forms the fruit with the calix which remains, either entirely or in part, ſolidly adhering to it.

C. The corolla, a membrane of the flower, generally coloured and brilliant; that which ſtrikes the eye the moſt, attracts the moſt notice, and really conſtitutes the flower in the opinion of the majority of mankind; a ſemi-tranſparent veil, which is in the neareſt contact with and ſupports the male organs of generation, continuation of the liber, or the cortical layers, is one of the parts which has moſt engaged the attention of botaniſts. It conſiſts either of a ſingle piece, in which caſe it is termed *monopetalous*, or of ſeveral pieces, when it is called *polypetalous*. Both of theſe corollas are either regular or irregular. The regular monopetalous corolla is termed campaniform when it reſembles a bell; infundibuliform when it reſembles a funnel. The irregular monopetalous corolla is *labiated* when it preſents the appearance of two lips at its orifice. The regular popetalous corolla is in the form of a croſs, *cruciform*; of a roſe, *roſaceous*; of a pink, *caryophyllated*; of a lily, *liliaceous*; of a butterfly, *papil-*

papilionaceous, or *leguminous*; both of them when without any determined form are termed *anomalous*. When the monopetalous coralla is very ſmall, and forms a long ſtraight tube, united in the ſame calix with many others, and terminated by five teeth, it is termed *floſculus*; when it is ſhaped into a tongue at its extremity, it is called *ſemi-floſculus*. The flowers that have no corolla are termed *apetalous*. In the petal, or each piece of the polypetálous flower, are diſtinguiſhed the claw *unguis* or narrow baſe by which it is inſerted, and the border or dilated part.

Linnæus compares the corolla with the curtains of the bed that conceal the married pair. When it is blown the fecundation is generally effected. Tournefort has founded his ſyſtem of botany upon the form of the corolla.

D. The nectary is an appendage or part of the corolla, which contains a ſaccharine and aromatic juice, called *nectar*, of which inſects, eſpecially bees, are very greedy, and which they form into honey. This organ is frequently a ſmall cavity, a ridge, a groove, one or more glands, a ſmall open round capſule, a fiſſure; ſometimes it is formed of branched hairs, a kind of tufts, horns, cowls, veſſels, ſpurs, cylinders, &c.: it exiſts in all corollas. The bottom or folds of thoſe which preſent no very diſtinct and well formed nectary, ſupply the place of it, and are found filled with a ſaccharine juice which filtrates in them.

E. The

E. The ſtamens, the male organs of generation in plants, form one of the moſt eſſential parts of the flower. When they are alone, the flower is ſaid to be *male*: they generally conſiſt of the *filament* and the *anthera*. The firſt is a ſupport through which the nouriſhment is conveyed to the anthera; the latter is a ſmall bag filled with fecundating powder or *pollen*; ſometimes the anthera has no filament. Modern botaniſts have much ſtudied the ſtructure and the diverſities of this important part of vegetables. They have diſtinguiſhed in it, eſpecially *a.* The number, which varies in different genera of plants, from one to ſeveral ſcore; *b.* The reſpective heights, which is either equal or unequal; in the latter caſe, when there are two large and two ſhort, they are termed *didynamic*; when there four large and two ſhort, they are *tetradynamic*; *c.* The form of the filaments, the form and the number of the anthers; *d.* Their ſeparation or their union; this is formed by means of fibres, when the name of *adelphia* is applied to them in general; *monadelphia* when they are united into a ſingle maſs; *diadelphia* when they conſtitute two; and *polyadelphia* when they form more than two bodies. The union is ſometimes effected by the anthers, they are termed *ſyngeneſia*; *e.* Their attachment, either to the receptacle, or upon the ovary, or to the calix, or to the corolla. The laſt mentioned inſertion always takes place when the corolla is monopetalous. Theſe poſitions are characterized

racterized by three modes of expreffion. The ftamen is faid to be *epigynous*, when it is attached above the germ, or to the germ itfelf; *hypogynous* when it is beneath, or adhering to the receptacle; *periginous* when it is round, or inferted upon the calix. When the monopetalous corolla is ftaminiferous, its infertion, which then determines that of the ftamens, is likewife triple. Linnæus invented an ingenious fyftem according to the number, the refpective fize, the fituation, &c. of the ftamens; and Juffieu has eftablifhed a ftill more profound and learned one, upon the manner in which the ftamina are inferted into the different parts of the flower.

F. The piftil, the female organ of generation is placed in the centre of the flower: it confifts of an inferior part or *ovary*, a fort of box or capfule, which contains the feeds, or determined by the feed or the feeds, even expofed in the bottom of the flower. This firft part is furmounted with a cylindrical canal, more or lefs long, termed the *ftyle;* the gardeners term it the fhaft in fruit trees; it has at its extremity, a kind of head, button, or horn, or a fomewhat dilated aperture, known by the name of *ftigma*. Sometimes the ftigma, without any intermediate ftyle, is fupported immediately upon the germen or ovary; in this cafe, it is termed a *feffile ftigma*. Since the ftamens have been more ftudied, the fame attention has been beftowed upon the ftyle, and the multitude of differences have been found,

found, and indicated in it. The number, the form, the refpective pofition of each part of the piftil has given rife to the adoption of a long feries of diftinctions: the pofition above or below the calix and the flower, has particularly been remarked; this is a conftant and very remarkable character of vegetables. Linnæus has alfo taken the conftant varieties of the piftils in different vegetables, for the eftablifhment of his fyftem, and he has made them conftitute the character of moft of his orders, or of the divifions of his claffes.

7. The relative pofition of the flowers is alfo one of the facts which moft influences the appearance and the external ftructure of the vegetables; they are either feffile, placed immediately upon the branches or twigs, or pedunculated, that is to fay, fuftained by a peduncule or fupport, more or lefs long, fhort, ftraight, crooked, rigid, pliable, inclined, moveable, agitated, ftrong or weak, capillary, &c. They are either folitary, or arranged two and two, three and three, four and four, axillary, terminal, caulinary, verticillated, in ftages, in ears, in umbellæ, in clufters, in corymbufes, in thyrfufes, in bouquets, in fafciæ, in paniculæ, in heads, balls, pyramids.

8. The fruit, which fucceeds the flower, the laft term in the work of vegetation, deftined to perpetuate the fpecies by the fucceffion of the individuals, is formed of one or more naked feeds contained at the bottom of the calyx, or of

of feeds folidly inclofed until their maturation, in coverings, which have been diftinguifhed according to the difference of their ftructure into feven fpecies. Four of thefe grow dry as they arrive at maturity; they are termed *capfule*, when the feeds are contained in them without attachment; *filique* or pod when they are attached to two fkins or valves feparated by an intermediate partition; *hufk* or *legume* when between two fkins or valves without partition, they are inferted on a fingle fide; *cone* when they are placed upon a conical axis, and covered with ligneous fhells which defend them. Three other fpecies of fruits remain fucculent; namely, the *nuts* or the kernel fruits, covered with pulp; the *apples*, or fruits with pepins, provided with a thick and tender parenchima; the *berries*, with a foft and femi-liquid pulp, in which the feeds are inferted without apparent order or attachment, *femina nidulantia*. All fruits open at a certain period, either by the drying of their fkins, and their elaftic feparation, which throws out and fows the grains, or by the decompofition of the pulp which conftitutes them, or by the fwelling and laceration of the woody fhells or horny capfules which inclofe the feeds. Methods or fyftems of botany have alfo been founded upon the ftructure and the difference of the fruits.

9. The feeds, the moft admirable and moft incomprehenfible part of vegetables, which contain them, completely formed within a very

ſmall volume, are in general compoſed of three ſubſtances: the *embryo*, the *cotyledon* or *cotyledons*, and the *periſperma*. Theſe three interior ſubſtances are enveloped in a thin and light pellicle, which is itſelf covered with a ſolid tegument, frequently horny or cartilaginous. The latter is alſo almoſt always provided with a fat, glutinous, reſinous, or mucous powder, which defends it againſt the action of external ſubſtances. This whole apparatus, which is alſo termed *grain*, varies prodigiouſly with reſpect to ſize and form. Some ſeeds are very large, whilſt others elude the ſight. They are ſpherical, rounded, compreſſed, ovoid, lenticular, cylindrical, reniform, ſubtriangular, ſubtetragonal, compreſſed, flattened, ſmooth, poliſhed, varniſhed, rough, rugous, furrowed, canulated, ſtriated, ſculptured, naked, dentàted, thorny, in the form of ſails, wings, tufts, plumes, pointed, edged, &c. &c.

A. The *embryo*, which is alſo termed the *plantula*, or *corculum*, contains the plumula, the radicle, and a part intermediary between both; it adheres to the cotyledon by one or two ligaments, which are compared with the umbilical cord in animals. It is a vegetable ſimilar to that which has given birth to it, the folded and implicated parts of which are to be developed by germination.

B. The term *cotyledon* implies a white, brittle, granulated ſubſtance, of a fine texture, which is eaſily reduced to powder, to which the embryo

embryo adheres. There are fome plants in which it has not yet been poffible to afcertain its exiftence, on account of the extreme fmallnefs of their feed; thefe are termed *acotyledonous*. There are fome in which this part confifts of a fingle piece; thefe are termed *monocotyledonous*. Many contain two very diftinct cotelydons, which may eafily be feparated from each other; thefe plants are diftinguifhed by the name *dycotyledonous*.

C. The *perifperma* is a third fubftance comprehended in the internal texture of feeds, almoft always fmaller than the cotyledons, more contiguous to the plantula, frequently furrounding it entirely, lodged together with it in the cotyledons, from which it is diftinguifhed by its colour, its texture, its tafte, which is almoft always acrid, whilft that of the cotyledons is generally infipid or mild. This fubftance is oleaginous, or carneous, or farinaceous, &c. It has not been well diftinguifhed and defcribed, except by the moft modern botanifts.

10. It is evident from this rapid fketch, which, however, is perfectly fufficient for the comprehenfion of all that relates to the chemical analyfis of vegetables, that this apparent and external ftructure already eftablifhes a very remarkable diftinction between thefe bodies, and thofe of which we have hitherto treated. It is not only by the great diffimilarity of the parts of which plants are compofed, whilft all the points of the fame foffil are exactly fimilar to

 each

each other; but ftill more efpecially by the intimate contexture, or the peculiar organization of thefe parts; that thefe beautiful productions of nature are ftill much farther removed from the mineral fubftances. It has formerly, but in vain, been attempted to eftablifh pretended analogies of ftructure between the moft regular foffils and the moft fimple of the plants; in vain has it been endeavoured to fupport thefe analogies by the figured ftones, the ftony dendrites, the herborizations, the fibrous ftones termed foffil linen, the configurations of ftones and metals in fern-leaves, &c. Cryftallization itfelf, a fort of regular and conftant geometrical arrangement of the molecules of minerals with refpect to each other, in which fome moderns have imagined they perceived a kind of almoft organized ftructure, is very far from being able to be confounded with the moft fimple of the vegetable organizations. This truth will be placed in the cleareft light by the expofition of the moft fimple notions, concerning the internal ftructure, or the anatomy of plants.

Article II.

Of the internal Structure or Anatomy of Vegetables.

1. All the parts of vegetables defcribed in the preceding article, which prefent themfelves at the mere view of thefe organized beings, which

which require no preparation or deſtruction in order to be obſerved or known, preſent in their internal parts, when diſſected, a ſtructure, a tiſſue, in a word, an organization widely different from the ſimple laminæ, or the cryſtalline and homogeneous molecules which conſtitute the foſſils. No one can fail of acquiring an idea of this difference, even in the exerciſe of the moſt ſimple arts, and in the moſt ordinary operations of life. In fact, when we wiſh to deſtroy the texture of any vegetable ſubſtance, we are obliged to go to work in a very different manner than when we break or pound a foſſil: the latter requires only a ſtroke or preſſure, and divides or elongates itſelf into molecules or ſurfaces that are ſimilar or perfectly identical. The vegetable, much leſs denſe in its texture, may eaſily be bent, momentaneouſly compreſſed, or even fractured by the efforts of the hands, by ſtroke, or by preſſure; but the neceſſity of cutting it, reducing it into fragments dividing it into pieces, extracting from it the liquids, which alſo are not found in the foſſils, has given riſe to the invention of wedges, axes, bills, knives, ſcythes, ſickles, ſaws, planes, chiſels, preſſes, and a number of other inſtruments, of which the mere uſe ſhows to the moſt uninſtructed workman, that the organized ſtructure of plants is extremely different from that of the ſtones, ſalts, or metals.

2. When the philoſopher was deſirous of making himſelf acquainted with the vegetable organization,

ation when he inveſtigated the texture of theſe bodies, with the aid of delicate inſtruments, by ſections made in different directions, the regular ſeparation of their fibres and layers, by means of maceration in water, of the moderate action of fire, and of the obſervation even of the phenomena and accidents which vegetables preſent during their life; when, I ſay, he inveſtigated the mode of this organization, he ſoon diſcovered that their different parts were a regular or co-ordinate aſſemblage of ſolid fibres, of channels or hollow veſſels, of liquids which circulate through them, of veſſels which receive them, of orifices which filtrate them either outwards or into cavities of internal reſervoirs, and that all theſe veſſels, intertwined with each other, and communicating amongſt themſelves, were the product of an infinite development, of a growth by intuſ-ſuſception, entirely different from the ſimple juxta-poſition which obtains in the minerals.

3. The labours and diſſections of Malpighi, Grew, and Duhamel, relative to vegetable anatomy, have ſhown that plants are formed of five orders of veſſels different in their organization, contained beſides in larger or ſmaller quantity, and diſpoſed amongſt themſelves in a particular manner, whether with reſpect to their reſpective arrangement, or to their number, in the different parts that have been deſcribed in the preceding article. The five orders of veſſels are, 1. The common veſſels; 2. the proper veſſels;

3. The

3. the tracheæ; 4. the utricles; 5. the veficular tiffue. It is effentially neceffary, in order to acquire an exact and general notion of the internal or anatomical ftructure of vegetables, to make one's felf well acquainted with the organization of thefe fyftems of veffels, the affemblage of which forms their texture.

4. Common or fap-veffels are thofe which are conftantly found in all vegetables, in all their parts, and which are deftined to convey the fap. In general, a large part of them are collected in the ftalk of plants, or the trunk of trees; they elevate themfelves perpendicularly from the root to the fummit of the vegetable; they turn themfelves laterally in all directions, leaving between them mefhes, or net-work, more or lefs contracted or dilated. It is not yet known whether thefe are real hollow channels, continued in their whole length, interrupted by kinds of hairs or valvules, as fome phylologifts have fuppofed; whether the fap is contained in their interior part, or whether it does not rather run upon the grooves or the external cavities with which they feem to be furrowed. It is generally believed that they pour this liquid into the utricles and the proper veffels: befides the fap, they alfo in fome cafes convey elaftic fluids. It is the layers and parcels of thefe veffels which conftitute the wood properly fo called, or at leaft which every where accompany it.

5. The proper veffels are fo named becaufe they are filled with juices peculiar to each vegetable,

getable, or to each part of the same vegetable. These are real secreting organs, which separate and retain, like real insulated reservoirs, the different humours of a particular nature, which ought not to be mixed with the common juice. They are almost always situated under the bark; round and below the first cortical layers; they are distinguished, when a stalk is cut in a direction perpendicular with its axis, by the drops of different coloured liquids, very distinct from the sap, which exsude from their open extremities. Sometimes they are dilated into vesicles or a kind of cells. They are connected with the common vessels.

6. The tracheæ, or air-vessels, are so termed on account of their resemblance with the organs which in insects are destined to transmit the air into every part of their bodies. These are very small filaments, more than capillary or setaceous, brilliant and silky at their surface, twisted into narrow spiral forms or worms, placed especially between the common vessels, and frequently running through and often filling up their intervals. They are distinguished in a piece of wood sawed or cleft longitudinally, by the small luminous lamellæ or spots, of a micaceous and argentine colour, which shine from all parts upon the surface of the wood, especially when it is exposed to the sun. They are obtained, insulated, and we observe them with their spiral structure very distinctly in the young twigs of the rose-shrub, when torn asunder

afunder, and not entirely filled. Though they feem to be deftined to convey the elaftic fluids, the tracheæ are frequently found full of fappy juice.

7. The utricular texture, compofed of fmall irregular facs, foft and compreffible, full of thick juice, are found collected in the pith of the ftalks; they appear to receive from fap-veffels, and to tranfport from thence into the proper veffels, the humours which they elaborate in their cavities, and to be efpecially deftined for the purpofes of nutrition. Thefe are the great terminations, or the centres of the abforbent veffels, like the thoracic duct or ducts in animals. Frequently they are filled with coloured juices. There are many vegetables in which this part becomes obliterated, and is afterwards fupplied only by the veficular texture. Moft of the plants, with a hollow or porous ftalk, prefent an admirable ftructure in the fafciæ of utricles, which occupy their centre. The nutritive matter is particularly contained in this texture, as in a refervoir.

8. The veficular or cellular texture is merely an expanfion, or a prolongation of the preceding texture. From the circumference of the utrico-medullary fafces proceed continued utricles, which paffing horizontally through the mefhes or areolæ left by the croffings and lateral divarications of the common veffels, proceed, diverging or elongating themfelves, to fpring forth above and on the outfide of the

cortical

cortical layers under the epidermis, where they pour out the reparatory juice which forms thefe layers. This ftructure is very marked, and very eafy to be difcerned in all the herbaceous plants, and in young woody plants. Very fenfible traces of it can be feen in the hardeft and oldeft wood: fuch are thofe ftellated rays, which in the trunk of a tree fawed through perpendicularly with its axis, proceed from the centre, and lofe themfelves under the bark. Between each layer of common veffels, this cellular texture, which is fo analogous to the cellular texture of the bodies of animals, forms an expanfion of a more rare or lefs denfe ftructure than thefe vafcular layers, which is preferved flexible and elaftic by the nutritive juice, which is there poured out.

9. From the aggregation and arrangement of thefe five orders of veffels refults the organization of the different parts which compofe the bodies of vegetables; and nothing is more proper than this confideration, to prove that this ftructure is extremely remote from the fimple juxta-pofition of the laminæ or the folids which conftitute the foffils. In thefe the difpofition of their molecules, even when regular and geometrical, depends only upon their primitive form, and their mutual attraction, modified by all the external circumftances which favour or diminifh their equillibration, their approximation, their cohefion. At whatever point of their continuity we examine the contexture of the

the parts of a foffil, whatever it may be, we always find only fimilar molecules or particles; in plants on the contrary, we perceive, at different points of their texture, diffimilar veffels, different organs, particular and different difpofitions of thefe veffels, communications, continued orifices of tubes or veffels, which prefent themfelves to the obferver.

10. It will not, however, be fufficient to confine ourfelves to this general confideration of the intimate ftructure of vegetables, in order to acquire an accurate idea of the differences which diftinguifh them from the minerals. We muft alfo inquire what differences this internal organization prefents in each of the fix different articles, of which it has been faid in the preceding article, that a perfect vegetable, or one complete in its organization, is compofed.

A. The fibrous root has the fame texture, the fame organization as the ligneous trunk or the wood: only its bark is never dry and hard, nor covered with a folid dry epidermis like that of the trunk. Moreover we find in it numerous filaments or fibres, filled with a multitude of abforbent veffels, deftined to fuck in the water and what it takes up from the earth, like fo many fyphons. In the carneous or tuberous root we fee no ligneous layers, but a fpecies of parenchyma lodged in a confiderable mafs of utricles or cellular texture.

B. The ftalk, or the trunk, is the part of vegetables in which we are beft able to difcern their

their texture and organization, eſpecially in that which is ſolid and ligneous, and which belongs to the trees. In this ſtalk we diſtinguiſh the bark and the wood. The bark, or the external tegument of the wood, and of all the parts of vegetables, is formed, eſpecially in trees, where we can ſee and detach it diſtinctly, of two very diſtinct parts, namely, the dry membranous epidermis, of a dark-grey, whitiſh or yellowiſh colour, compoſed of ſmall, brittle, ſemi-tranſparent plates; and the cortical layers, applied in looſe contexture the one above the other, eaſily to be ſeparated into leaves, which are termed *liber*, and frequently filled with liquid conveyed to them by the extremities of the medullary prolongations, which ſpread themſelves out upon them. The interior layers of the *liber* become, every year, an external layer of wood: this, the wood, a contexture of common veſſels, proper veſſels, tracheæ, utricular tiſſue, preſents a medullary centre, prolongations proceeding from thence, and ſpreading out under the epidermis, annual layers of ligneous texture, which indicate the years of its growth; the interior of which, being the hardeſt, form the heart, and the exterior the ſofteſt, called the ſap.

C. The leaves covered with the epidermis, which is common to all parts of the vegetable, conſiſt of a great quantity of common veſſels, the diviſions of which form a very numerous areolæ, filled up with flat webs of utricular texture, into which a thick juice, frequently viſ-

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cous and gluey, is poured out. The veſſels which are tranſmitted into it by the petiole, in which they are ſqueezed together, diverge and ſeparate into diviſions perceptible to the eye in fibrous lines, and ſpread out in the plane ſurface of this part. The leaves may be very well diſſected by maceration in water; they are alſo diſſected by the inſects, which eat the bark and parenchyma, ſo as to leave only the vaſcular texture inſulated. They are perforated at their upper and under ſurface, with a great number of pores, which exhale or inhale vapours or elaſtic fluids.

D. In the flowers, the calixes are abſolutely of the ſame texture as the external parts of the bark, or as the epidermis; they are in fact formed of the epidermis ſpread out, and ſometimes ſwelled. The corollæ are a continuation of the liber, and contain alſo an immenſe quantity of tracheæ, ſo that they may be conſidered as a kind of pulmonary organ in vegetables. The ſtamens are continuous with the interior woody texture, and the proper veſſels; the antheræ are ſmall membranous purſes, folded double, entirely perforated with pores through which a matter exſudes in ſmall drops, which afterwards dries and becomes the pollen, the fecundating powder. The piſtil, a continuation of the utricular or medullary texture, has been compared with the female organs of generation in animals; the ſtigma holding the place of the vulva, the ſtyle of the vagina, and the ovary of of the uterus. The vegetable eggs, or the ſeeds, are intirely formed in theſe organs, in which they exiſt previous to fecundation. From this ſtructure of the flower it reſults that it may be conſidered as the ultimate production of the different orders of internal veſſels, as their laſt ſhoot, as a ſpecies of dilatation or ſeparation of the different internal organs; they are the admirable product of the exceſs of nouriſhment and motion in the different orders of veſſels which conſtitute the internal texture of the plant.

E. The fruits are almoſt always formed in their interior part of a pulpy, fleſhy, gelatinous, flabby parenchyma, which conſiſts almoſt entirely of utricular texture, and through which only ſome common veſſels tranſmitted by the peduncule paſs: theſe veſſels, which generally paſs into the centre of the fruits, carry nouriſhment to the ſeeds, and produce, by the effuſion of the ligneous juice, the ſhell which frequently ſurrounds the kernels. Sometimes this ſuperabundant ligneous juice depoſits itſelf in the parenchyma, forming concretions which are often improperly termed ſtones.

F. The ſeeds alſo are formed by the utricular texture, in the veſicles of which a pulverulent, or mucous, or dry and feculent matter is depoſited, which communicates immediately by a kind of umbilical cord with the plantula, which it furniſhes with the firſt nouriſhment, in in order to effect the development which takes place in germination. It cannot be doubted that the juice depofited in this organ is the moft elaborated, the moft perfect, and the moft precious product of the nutrition of the vegetables, as it gives birth to the moft ufeful part, deftined to maintain and multiply the fpecies in fimilar individuals, which fucceed each other without interruption.

ARTICLE III.

Of the Phenomena of Vegetable Life.

1. As vegetables differ fingularly from the minerals or foffils in their afpect, their appearance, their external and internal ftructure, this difference is found ftill more prominent and decided, when we confider the play of the organs of which they are conftituted. Vegetables have already been faid to differ from minerals, in their being nourifhed or increafed by intuffufception, whilft foffils increafe merely by the approximation and external addition of fimilar molecules. However, this general enunciation is not fufficient accurately to eftablifh the differences which exift between thefe two claffes of bodies.

2. It is from the fame action of the parts, from the functions that are exercifed by the different veffels of vegetables, that we are to derive a more precife

precife notion of their differences from the inorganic laminæ of minerals. The aggregate of the phenomena which take place in the organifm of vegetables conftitutes a particular life. Vegetables are juftly faid to live; for we fee their birth, development, and growth; their exiftence, and the phafes of this vegetable life divided into feveral ftages, which fucceed each other, and each of which prefent different fcenes dependent the one upon the other; we fee them ceafe to grow at a certain period, become fit for generation when they have acquired their full growth, remain for a longer or fhorter time more or lefs healthy, and vigorous in their adult date; give birth to a numerous progeny, afterwards droop, become enfeebled, deteriorated, even fall fick, fubjected to the inevitable lot of whatever poffeffes life, and at length arrive as the final termination of their exiftence, or death.

3. All thefe tranfitions, all thefe periods of vegetable life, which remove them far from the foffil compounds and approach them to the animals, are effected by an internal procefs, by fucceffive changes which take place in the cavities of the different orders of the veffels which conftitute their texture; and thefe changes are executed by means of regular and conftant motions, which are called vegetable functions. It is not our prefent object to determine either the caufes or the particular refults of thefe functions. Our prefent object is merely to afcertain their exiftence,

ence, to announce its figns or phenomena, in order that we may be enabled to eftablifh, in a certain manner, the difference between vegetables and animals.

4. Obfervation alone is fufficient to fhow that there takes place in vegetables,

a. An abforption of the liquids and fluids placed around them.

b. A motion of fluids from one part to another.

c. A modification of thefe abforbed liquids and fluids.

d. A feparation of thefe liquids into different cavities, and into different natures.

e. A development of the organs or progreffive growth.

f. An ejection of a portion of thefe bodies fuperfluous for nutrition.

g. A motion in fome of their folids.

h. A folidification, or a formation of folid, which becomes ligneous fubftance.

i. A re-production of the individual.

We muft caft a glance upon each of thefe phenomena.

5. The abforption of liquids and fluids by the pores of vegetables is a phenomenon equally certain and eafy to be appreciated. The tubes of the roots, and the pores of the leaves, are the principal organs of this abforption: this is proved by the immerfion of thofe parts into coloured liquids, and the paffage of thefe liquids into the veffels of the plant. In this confifts

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what is termed intuſ-ſuſception. It is by this means that vegetables imbibe their nouriſhment, that the manures increaſe their growth or change their quality, and that ſoils influence all their properties.

6. Theſe abſorbed liquids form the ſap, which in the ſpring diſtends the common veſſels; and even, when it is very abundant, the tracheæ, the proper veſſels and the utricles; it appears to move from the root or the bottom of the plant upwards into the ſtalks and branches; ſome authors believe that it deſcends again under the bark, and that thus a real circulation takes place. It is proved by means of ligatures, by the ſwellings which they occaſion, by the exſudations and lachrymations which it produces, the inflation of the bark. All the other proper liquids are diffuſed by degrees into their particular veſſels, effuſed into cavities or reſervoirs, and thus tranſported from one place to another.

7. In proportion as the liquids abſorbed are moved in the canals of plants, and circulate in them, they become modified, their nature is changed, they become the different peculiar juices, and acquire properties which render them capable of fulfilling the different uſes for which they are deſtined. In this manner are formed all the different materials of veſſels which we ſhall ſoon examine. Theſe modifications are ſo many chemical products or effects, which can be appreciated when the nature of theſe materials ſhall

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have been explained, and compared with that of the nutritive fubftances which they abforb, and which pafs into their tubes. This fecond feries of phenomena anfwers to digeftion.

8. In proportion as thefe modifications take place, and as the homogeneous liquid, known by the name of fap, is converted into different proper juices which are to become the feveral materials of the vegetables, thefe juices are rejected or feparated from the general mafs of fap, carried by particular channels into various refervoirs; and this phenomenon has the greateft analogy with what is called fecretion in animals.

9. From thefe firft effects, the abforption, the motion, the fucceffive change, and the regular fecretion of the vegetable liquids, follows the development, the evolution of the organs which contain them, and thence the growth, the elongation, and the augmentation of volume which they experience. This is a nutrition exactly fimilar to that of animals. In it we fee the liquids become thickened, affume a confiderable confiftence, become coagulated, changed actually into folids, and thus add, as far as a certain term, that of the expanfion which the fibres are capable of affuming, to the layers of the trees. It is by this effect that the diftended bark cracks, is feparated, and becomes unequal, rugged, furrowed, &c.

10. This development, this growth of the fibres and the layers which employs the thick-

ened liquids, does not abſorb them intirely. All the matter taken as nouriſhment by the vegetables, and derived from the ſoil, the air, the manures, the water, does not remain intirely in their body. The uſeleſs or ſuperfluous part is evacuated either in the form of liquids which run out by external orifices, or of elaſtic fluids which eſcape by tranſpiration. We ſhall ſee the nature of both hereafter. Theſe excretions, which are ſufficiently proved by a multitude of facts are alſo perfectly analogous with what takes place in animals.

Simple obſervation proves alſo, that at different periods of the vegetable life, and even for the exerciſe of the functions which they perform, ſeveral of their parts execute motions which have ſome relation with thoſe which we obſerve in animals. Thus the petioles of the leaves bend, fold themſelves, approach nearer to or remove to a greater diſtance from the ſtalks and the branches; thus the motion of contortion or flexure is almoſt general in the leaves which follow the courſe of the ſun, and of which the inferior ſide is always turned towards the ground, whilſt the ſuperior is always directed towards the ſky and the light; thus the herbaceous ſtalks incline themſelves imperceptibly towards illuminated places. This phenomenon, which approaches to the nature of animal irritability and galvaniſm, is ſo ſenſible and ſo decided in ſome plants, that they fold themſelves at the approach of all irritating ſub-

ſtances,

ſtances, and almoſt at every kind of contact, as we ſee in the Senſitive Plant: other parts, and eſpecially the filaments of the ſtamina, preſent it in a ſtill more diſtinctly marked manner, and incline themſelves almoſt ſuddenly towards the piſtil when we irritate them with pointed ſubſtances, as we obſerve in the helianthus rue, the barberry buſh, &c. Modern botaniſts have paid much attention to this motion of vegetable irritability; and the more the facts relative to this point in Natural Philoſophy ſhall be multiplied, the more this phenomenon will be generalized.

12. The conſtant term of nutrition and growth in vegetables is the ſolidity which theſe beings acquire in the ligneous ſtate at which they arrive: thus the production of the wood, and the converſion of all their parts into ligneous ſubſtance, reſemble here that oſſification which in the ſame manner terminates the life of animals. Every thing proves that the ſubſtances by which plants are nouriſhed are carried in the ſtate of liquids into their ſtrainers, and that they at laſt become ſolid, loſe their ſolvent, and aſſume the concrete form Our preſent object is only to eſtabliſh the exiſtence and the generality of the phenomena, not to explain them. Accordingly, I muſt confine myſelf to the enunciation of what happens, without endeavouring to aſcertain the cauſes which ſhall be explained after having ſtudied the nature and the compoſition of the vegetable ſubſtances.

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13. One of the moſt incomprehenſible and moſt beautiful phenomena in vegetable life is their re-production. The duſt of the ſtamens, received upon the ſtigma, fecundates the ſeeds contained in the ovary. This is proved by taking away the ſtamens or the antherefe, which leaves the plant barren: it is proved alſo by the hiſtory of the female flowers of the monoecial plants, which do not bear any fruit, unleſs there are ſome male individuals in their reach, by the manner even in which they are fecundated by ſhaking the powder of the ſtamens upon their piſtils; finally, it is proved by the varieties which the ſeeds of trees yield, when fecundated by the ſtamens of other vegetables. The ſeeds pre-exiſt in the ovaries, and the pollen only produces in them the vital motion, or the diſpoſition to contract it. Without this fecundating powder, the ſeeds wither and dry away within their coverings. Scarcely has it touched them, or penetrated them with the vapour which exhales from it (for we do not ſee the whole pollen paſs intire into the ovary), when this diſtends, grows, becomes the fruit, and the ſeed which it contains has become fruitful. After this, when buried in the earth, or penetrated with moiſture, it ſwells, the radicle becomes elongated, and deſcends into the ground; the plumula, equally elongated, elevates itſelf into the air, carrying with it the colyledons which preſent the two firſt leaves, or the firſt leaf, which on that account are termed

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feminal leaves. When once it has fprung forth into the air and taken root in the ground, the young plant lives by its own ftrength; nourifhed at firft by its own fubftance of perifperma, which forms a kind of milk, the embryo is developed, unfolded, quits this nutrient integument, and draws in its nourifhment by its own abforbent pores.

14. To this feries of phenomena, eafy to be diftinguifhed, and which conftitute the vital functions of vegetables, we muft add the property which plants poffefs, of being re-produced or propagated by flips, of uniting by their divided barks, of entering the one into the other, of being multiplied by fuckers, of being varied and married one with another by grafting: we muft alfo add that germination, foliation, floration, and fructification, divide their life into diftinct periods; that every year the moft of them repofe during the winter, fleep during the cold, and begin again to live in the warm feafon; and we fhall have in this delineation, however feebly it may be fketched, a collection of facts which will leave no doubt with refpect to the extreme difference which exifts between thefe beings really organized, and the brute and inorganic matters that have been treated of in all the preceding fections. It will eafily be conceived that the chemical properties of thefe bodies muft be very different from thofe of the foffils, and that the manner of appreciating them

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muft be no lefs different from that which has been applied to thofe. This is the only truth which I have hitherto endeavoured to prove; and I fhall finally confirm it by confidering, in a laft article of this firft order, the general ufes which vegetables fulfil in the economy of nature, and by comparing them with thofe to which minerals are deftined.

ARTICLE IV.

Of the Ufes or Functions of Vegetables in the Economy of Nature.

1. WHEN we employ ourfelves with inveftigating the rank which vegetables hold amongft the productions of nature, and the ufes for which they are deftined, we difcover, efpecially in this inveftigation, the moft prominent difference between the minerals and thefe organized beings. Elevated above the furface of the globe, covering its nakednefs, enriching its drynefs, and fubftituting, inftead of its aridity, the image of frefhnefs and abundance, the vegetables feem to conceal from the eyes of man the foffils which the earth contains in its bofom, and to invite them to enjoyments which the minerals cannot procure him. Their maffes fhooting up into the air in the form of trees, or preffing upon the ground which they adorn with a brilliant clothing of verdure, prefent equally

equally, in all points of the globe, the moſt beautiful, the moſt gay, the moſt delightful of ſpectacles, and no animated being is inſenſible to this rich veſture of the earth.

2. The force with which it vegetates, grows, and augments in all dimenſions, when it meets with no obſtacle, when the hand of man does not deſtroy or ſtop it in its courſe, tends to overcharge the ſurface of the earth with ligneous ſubſtance; and if we except the height of mountains above 3000 metres in the atmoſphere, which ſhows the ſtony ſkeleton of the globe, always bare and always naked, the whole cruſt of our planet would be intirely covered with trees and wood. We ſee this in the places where men have not yet fixed their abode; impenetrable foreſts, maſſes of wood in cloſe proximity with each other, occupy the whole ſpace, and reign unmoleſted in it.

3. Thoſe among theſe organic beings which, by the laws which every thing obeys, and after having fulfilled the limits of duration which nature accords to their exiſtence, have periſhed, fall upon the ground, are ſlowly decompoſed, and converted into a nutritious *detritus*, into an earth or ſoil of new formation, which forming layers ſucceſſively applied over the primitive beds of foſſils, gradually raiſe this ſoil, change the proportions of its principles, and conſtitute a maſs of natural manure in which the ſeeds vegetate with rapidity. Thus even, from the ſucceſſive death and decompoſition of the one, the

the others derive the ſource of their life and their ſtrength, in order in their turn to furniſh an aliment to the vegetable generation which is to ſucceed them: an admirable uninterrupted circle of the regenerating power which watches over the preſervation of all the productions of nature.

4. Theſe immenſe maſſes of vegetables which ſurmount the foſſils, and reign over them, detain at the ſame time, at the ſurface, the water, that firſt ſource of vegetable fertility, prevent or diminiſh its evaporation, abſorb it from all parts, appropriate it to themſelves, drink it by all their pores, produce the ſame effect upon the clouds or water in the ſtate of vapour, attract them, condenſe them, open myriads of greedy mouths to imbibe them, and frequently retard or annihilate the dangers of heavy rains or ſtorms for the towns which theſe clouds threaten to deſtroy. Thus it has been obſerved, that foreſts inconſiderately hewn down in the vicinity of ſome towns have rendered them infinitely more ſubject to atmoſpheric torrents or abundant rains.

5. The vegetables, by the intermixture of their roots, and the adheſion which they contract with the earth which ſurrounds them, ſuſtain the moſt moveable and leaſt tenacious parts of the ſoil, the ſhrinking of which they retard or intirely prevent; they even defend the ſoil from the undermining action of the water. Human induſtry has availed itſelf of this property,

perty, in order to give folidity to places moft liable to be undermined or to fink, whether in confequence of the want of cohefion in the earth that covers them, or on account of the declivity of the layers upon which this earth refts, efpecially when they are attacked by the motion of the water.

6. Whilft they prefent to man the moft magnificent fpectacles, vegetables are deftined by nature to renovate, by the aid even of their vital motions, the purity and primitive compofition of the air neceffary for the fupport of the life of animals. When acted upon by the rays of the fun, they pour into the atmofphere a vivifying ftream of oxigen gas, in proportion as they vegetate.

7. The vegetables afford at the fame time a defence againft the heat of the fun, a falutary and refrefhing fhade to animals. Under their leafy vault animated beings find repofe, coolnefs, and fhelter againft the winds, rains, and ftorms; from them they at the fame time derive their nourifhment: this is the moft important purpofe which plants are deftined to fulfil in nature. Accordingly, under the denfe fhades of vegetables, accumulated together upon inhabited regions, and even in the very bofom of the humid flime, or the ftagnating waters which their maffes fupport, dwell immenfe nations of reptiles, ferpents, aquatic birds, infects, and worms.

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8. All the facts that have been collected relative to the economy of nature prove, that no animal can support its existence upon the fossile substances, and that without vegetables there would be no animals. It is in these organized bodies that all the classes of animals find their primitive nourishment: for those that live upon other animals devour such as nourish themselves with vegetables. Thus every living body comprehended in the numerous class of animal beings derives its first existence from the plants; thus the vegetables are destined by nature to prepare the primitive aliment of animals, and no substance can be digested by these, unless it has been previously prepared by the interior organs of plants. Considered in this extensive point of view the vegetables are a kind of beings necessarily intermediate between the fossils and the animals; they receive primitively from the first the elements of brute and inorganic matter, which they combine in a complex manner, in order to furnish it to the second, in which it is then susceptible of being converted into their own substance. They are destined to prepare the aliment of animals; accordingly, the number and the weight of these correspond very exactly with the number and weight of the former. Were there only this difference between the fossils and the vegetables, it would be sufficient to distinguish them in such a manner that they could never be confounded.

9. To thefe great ufes in the economy of nature, human induftry, and the perfectibility of which man is fufceptible, have joined an immenfe number for his neceffities and pleafures. Without attempting the flighteft fketch in this place of the arts which are exercifed upon vegetables or vegetable matter, a fubject which will be treated in moft of the articles of this fection, it will be fufficient to obferve that men find in thefe beings, a great variety of foods together with the moft commodious matter for building their habitations, that of their clothing, the remedies for the difeafes to which they are fubject, even the means of tranfporting themfelves over the waves, the materials of almoft all the machines which they conftruct and employ, efpecially for moving, raifing, and drawing heavy burthens. They have been able to collect about them ufeful plants of all kinds, to multiply them, to increafe their production by culture, to perfect and modify their properties in a thoufand ways, to give them dimenfions, odours, taftes, colours which not originally belonged to them, and to appropriate them in general to their wants and even their caprices.

Second Order of Facts relative to the Vegetable Compounds.

Of the Nature or Chemical Compofition of thofe Beings in general.

ARTICLE I.

Concerning the Succeffion of Labours and Difcoveries relative to this Compofition.

1. IT is impoffible to avoid concluding, from the facts which have been collected in the preceding order, that the vegetable organization muft form compounds extremely different from thofe which conftitute the foffils, and that the chemical phenomena which thefe compounds prefent muft alfo be entirely different from the refults which we obtain in treating mineral fubftances. Hence in the firft labours which chemifts have beftowed upon the vegetable fubftances, they obtained facts oppofite in fome meafure to thofe which they had occafion to obferve in the foffils. All the phenomena of the analyfes were then fo much confounded and mingled with each other in their experiments upon thefe organized bodies, that it required much time and great progreffion, in the general theory of the fcience, before they were able to conceive the general caufe of this difference, in the complication even of the effects, combined by the analytic action to which they fubjected them.

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2. One of the firſt and moſt aſtoniſhing data which they collected in their rude aſſays upon the vegetable ſubſtances, was the impoſſibility which they found of reſtoring to theſe ſubſtances, when once altered by chemical operations, the original compoſition and nature which they had before. Whilſt the mineral compounds, when analyzed with care, afforded them principles which, when re-united or combined in the proportions indicated by this analyſis, formed again the compounds with all their properties, they were unable to obtain any thing ſimilar by their experiments upon the vegetable compounds; and they remained a long time ignorant what was the reaſon of this phenomenon; ſo that they muſt have deſpaired of ever arriving at an exact notion of the compoſition of thoſe beings which thus preſented them, prior to the pneumatic doctrine, only an inſoluble problem, an inexplicable enigma.

3. Accordingly, the whole of vegetable chemiſtry was ſtill confined in 1784, to the extraction and purification of the different immediate products of plants, to the determining their relative ſolvents, to the ſearch for the means of ſeparating them exactly, the ſeizing the principal characters which diſtinguiſhed each of theſe products, in order rather to make them ſubſervient to our wants, than exactly to appreciate their nature. Confined during more than an age to the laboratories of pharmacy, or the workſhops of the arts, this part of chemiſtry was occupied

cupied only with the preparation of medicines, and the production of the different ſubſtances uſeful to men for their numerous wants. If at this period we had ſought philoſophical ideas concerning the nature of vegetables in the analyſis which the chemiſts made of them, we ſhould have found nothing but errors or hypotheſes: and if we had expunged from the treatiſes of chemiſtry what related to pharmacology or the manufactures, nothing would have been left for chemical philoſophy.

4. After the ſimple and often mechanical means of extraction of the principal materials of vegetables, given by the firſt chemiſts, with the ſpecial intention of forming uſeful medicines from them, there was firſt adopted, in order to inveſtigate the nature of theſe materials, and alſo that of the entire vegetables, the violent action of fire, by diſtillation in the retort; and it was ſo firmly believed, that the principles ſo obtained, had exiſted ready formed in them, and were only ſeparated by the heat, that no other method of explaining their virtues was uſed, than that of attributing them to theſe principles. This we particularly remark in the works of Lemery, Geoffroy, and all the authors of the materia medica, from the end of the ſeventeenth till nearly the middle of the eighteenth century. The Academy of Sciences at Paris, even believed that one of the moſt important and moſt neceſſary labours to which they ought to devote themſelves, was the ana-

lyfis of plants by fire; and nearly thirty fucceffive years were employed in the execution of this enterprize, recorded and defcribed with great care in three large folio MS. volumes, preferved in the library of the Inftitutes, the fruit of the labours of a Boulduc, a Dodart, a Geoffroy, a Bourdelin, &c.

5. At laft this method of analyfis was perceived to be fallacious, and that by following this route one was led afide from the path of truth, for corn and hemlock afforded products almoft fimilar to each other. The chemifts were then for fome time totally difcouraged, until, always tormented by the almoft exclufive wifh to extract valuable medicines from vegetables, they adopted a new courfe, that of re-agents. They began to treat vegetables and their materials with cold and hot water, and with alcohol, to compare the different effects of thefe two liquors. Boulduc, Hermann, and Cartheufer, drew fome ufeful refults from this method. They calculated the different proportions of the aqueous and refinous extracts feparated by this means. La Garaie taught the art of extracting the foluble materials by means of cold water applied to the vegetables in a ftate of minute divifion, with the aid of motion communicated by agitators, and of obtaining from them unaltered principles. The books of pharmacology, and of the materia medica, treated then of the virtues of plants, according to this new mode of analyfis;

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and the firſt error, proceeding from the altering action of the fire, being ſucceſſively corrected by leſs erroneous reſults, gradually diſappeared.

6. A little after the middle of the eighteenth century, Baccari, in Italy, and Keſſel-Meyer, in Germany, found in the application of cold water, a new mode of analyzing the farina of corn, and diſcovered the glutinous matter, the new vegeto-animal principle, a diſcovery which animated the chemiſts with new courage. Rouelle who, in his courſe, had already added much to Boerhaave's beautiful ſcheme of the vegetable analyſis, was the firſt who diſtinguiſhed with more care the immediate materials of vegetables, divided and characterized the different kinds of extracts by better known properties; diſcovered the glutinous matter in the green leaves, compared the gums and the ſugar with the ſtarch; publiſhed in his proceſſes a more complete and eſpecially a more methodical ſketch of vegetable analyſis than had till then been exhibited, and re-animated the hopes of the labourers of chemiſtry. Bucquet, my firſt maſter, whoſe life was too ſhort for the intereſts of ſcience, publiſhed in the year 1773, under the modeſt title of *Introduction à l'étude des corps naturels tirés du règne végétal*, a work of the higheſt value for the order which reigns in it, and the deſcription of the numerous parts relative to the chemiſtry of plants. At this period every thing was diſpoſed for more important diſcoveries.

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7. The pneumatic chemiſtry then began to ariſe, when Prieſtley and Chaulnes examined the acid gas, then termed *fixed air*, produced and diſengaged during the vinous fermentation, and convinced themſelves that it was the ſame as that which Black had found in chalk and the alkalis. Already in 1764, Macbride had admitted its preſence in vegetables, in a manner too precipitate indeed, but ingenious, and calculated to give an uſeful impulſe to the minds of men, and had attributed the putrid decompoſition to its diſengagement; accordingly to him, nothing more was required than to prevent this diſengagement, or to reſtore this principle to vegetables, in order to prevent or correct their ſeptic alteration. Though this firſt introduction of the pneumatic chemiſtry into the analyſis of vegetables, from 1764 to 1784, gave riſe only to falſe notions, it was, however, of ſervice to the ſcience by the diſcoveries, inſulated and incoherent indeed, which it produced. The epocha of the diſcovery of the nature of water, followed ſoon by that of the nature of fixed air, which was found to be carbonic acid, was a flaſh of light for vegetable analyſis. Lavoiſier, by examining the products of the combuſtion of oil and of alcohol; by obtaining more water than their own weight amongſt theſe products, as well as a remarkable quantity of carbonic acid gas; by ſtudying with equal care the phenomena of vinous fermentation, opened a new path, and threw a great light upon the vegeta-

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ble compofition; explained the nature and the fource of the products which till then had been extracted by means of fire, why they could not be contained in the vegetables previous to this action, how they were formed. Thus the firft accurate notion of the organic compounds prefented itfelf. Since this illuftrious period the fteps of the chemifts, which halted before, have become fteady; the fcience has proceeded from difcovery to difcovery. There has particularly refulted from it an ingenious and ufeful comparifon between the different means of analyfis till then employed, that by fire, by combuftion, by diftillation, by fermentation. Hence alfo arofe the fimple idea of vegetable compofition, which will be traced in one of the fubfequent articles. My defign here is merely to prefent in a fingle point of view, and under a fingle feature, the refult of Lavoifier's labours upon vegetables.

8. All the difcoveries relative to vegetable analyfis, which have been made either fome years before 1784, or fince, may be referred to the new ideas diffufed by Lavoifier, of which they are only approximations and neceffary confequences. It is in this order that we ought to place thofe of Bergman and of Scheele, efpecially of the latter, who has done more towards the improvement of this analyfis, than all the chemifts collectively had done from the commencement of their labours. Prior to thefe, fcarcely two or three vegetable acids different from

from each other were known. In 1776, Bergman diſcovered the converſion of ſugar into a particular acid by means of the nitric acid, and Scheele ſoon found that this acid was the ſame as that of ſorrel; and from this firſt ſource of the artificial fabrication of a vegetable acid have proceeded many other ſimilar diſcoveries. The laſt mentioned chemiſt ſucceſſively diſcovered the particular exiſtence of the citric, the malic, the gallic, the ſacchlactic acids, and gave occaſion to the ſucceſſive labours of Crell, Hermſtaedt, Weſtrumb, Koſegarten, and Brugnatelli, relative to the formation, the reſemblance, the difference, and the mutual converſion of the acids; diſcoveries which have furniſhed the French chemiſtry with the opportunity of applying its doctrine in ſo happy a manner, as we ſhall ſoon ſee, to the nature and compoſition of all the vegetable ſubſtances. I do not here ſpeak of many other particular facts which we owe to the ſame Swediſh and German chemiſts, and which I ſhall have occaſion to quote elſewhere.

9. During, or ſhortly after, theſe uſeful diſcoveries of the Swediſh and German chemiſts, Ingenhouſz and Sennebier, examined the elaſtic fluids exhaled from plants, the action of vegetables upon different kinds of gas, their influence upon the air, and that of this fluid, of water, and of light upon the vegetables. Their labours approach in a ſingular manner to the firſt data found by Lavoiſier; and though they had taken routes entirely contrary, they in ſome

ſome meaſure met in the career which they had run, by beginning each at oppoſite extremities. Hence reſults the moſt beautiful conformity that can be found in the hiſtory of the ſciences; and it is from a compariſon of the collective maſs of their labours, that the important application has ſprung which has began to be made of the truths of chemiſtry to the phenomena of vegetation. It is from this period that the happy revolution that has been effected in vegetable phyſics truly dates itſelf; a revolution, the actual ſtate of which I ſhall delineate, after having conſidered all the facts which conſtitute the whole of the analyſis of plants which at preſent exiſt.

10. Citizen Berthollet has, on his part, rendered the moſt important ſervices to vegetable analyſis. His labours upon the oxigenated muriatic acid led him, in examining its action upon the vegetable colouring ſubſtances, to determine its nature, and the diverſities of its colours, to explain their alterations by the air, and to underſtand the remarkable influence of oxigen upon the oils, which it thickens, and cauſes to paſs into the ſtate of butter or wax. By other experiments and reſearches, he has diſcovered the ſlow and ſpontaneous decompoſition of the tartarous and acetous acids, and of their ſalts diſſolved in water, the portion of pot-aſh ready formed, which the firſt contains, the attraction of the colouring matters for alumine, and for the oxide of tin, the decompoſitions of the tartrite of

of antimony, and of the ſuper-oxigenated muriate of mercury by the decoctions of Peruvian bark. May I be allowed to rank myſelf amongſt the liſt of chemiſts who have improved the vegetable analyſis, on account of the reſults which I have publiſhed in various particular diſſertations, relative to the different coloration of the extractive matters by different proportions of oxigen; concerning the properties of the extracts deſcribed in my analyſis of the Peruvian bark; concerning the converſion of the ligneous ſubſtance into ſeveral acids by the nitric acid; concerning the ſeparation of elaſtic caoutchouc from the juice of the hevæa expoſed to the air; concerning the reciprocal action of the nitric, ſulphuric, muriatic acids, and the vegetable ſubſtances. I have, moreover, undertaken an extenſive courſe of inquiries upon vegetable analyſis in general, in conjunction with Citizen Vauquelin, of which I ſhall exhibit ſome portions in this work, though theſe inquiries are yet far from being completed. I paſs over in ſilence a great number of other tracts in the hiſtory of vegetable chemiſtry, and the diſcoveries which we owe to M. Prouſt, to Pelletier, to Citizen Chaptal, who has rendered great ſervices to the chemical arts relative to theſe ſubſtances, to Citizens Deyeux and Vauquelin, and to ſeveral other chemiſts, as theſe facts will find their place in moſt of the ſubſequent articles, and as moſt of them do not preſent that generality of reſults which alone can make them

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be confidered here as having influenced the progrefs of this part of the fcience. My intention was here only to announce or exhibit the moft prominent traits of different epochas of the analyfis of vegetables, thofe which have really changed the face of the fcience, and have raifed it to that degree of elevation at which it has arrived.

Article II.

Of the different Methods of Vegetable Analyfis, compared with each other.

1. FROM what has been explained, though very fuccinctly, in the preceding article, it refults, that at the different periods through which the art of chemiftry has in fome meafure paffed before it arrived at that period of improvement which it now has attained, the methods of analyfing vegetables muft have varied, and actually have varied. However, nothing has been loft in this refpect; even the faults of the antient methods have been turned to advantage; ufeful inductions have been drawn from them towards the eftablifhment of new ones; they have been compared with each other, and this comparifon itfelf has furnifhed new and fometimes unexpected lights. In proportion as by rectifying its errors, chemiftry has created new methods, it has not entirely abandoned the ancient ones; it has refumed them under a new

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point of view, and corrected them; ſo that even the inaccuracies of their reſults have then given place to poſitive data. Theſe methods have therefore mutually checked each other.

2. When we conſider, under one point of view, all that has been done more than a century paſt relative to the analyſis of vegetables, and bring together the different means ſucceſſively employed for inveſtigating the nature of plants, we may refer all the modes of treating them that have been adopted, to eight general methods; namely,

a. The natural mechanical analyſis.
b. The artificial mechanical analyſis.
c. The analyſis by diſtillation.
d. The analyſis by combuſtion.
e. The analyſis by water.
f. The analyſis by the acids and the alkalis.
g. The analyſis by alcohol and the oils.
h. The analyſis by fermentation.

By giving a conciſe notion of the operations and uſes of each of theſe kinds of analyſis, we do not yet attempt to determine with exactneſs the chemical properties of vegetable ſubſtances. This ſubject belongs to the third order of facts, which ſhall be treated of in particular after this; but we only continue to exhibit the means which chemiſts have taken in order to arrive at the knowledge of theſe properties, and acquire an accurate idea of the difference between vegetable and foſſil ſubſtances; in a word, it is only a ſequel, and one of of the neceffary portions of the hiftorical part which forms the general fubject of the four articles comprehended in this fecond order of facts.

3. Though the feparation of the different fubftances of which vegetables are compofed, effected by mechanical means, is not really comparable with the means of chemical analyfis, I rank it amongft the methods of analyzing plants, becaufe it actually ferves to infulate the materials of which they are conftituted. This firft means I term the *natural mechanical analyfis*, becaufe it is effected by nature. When any proper or particular humour fwells the veffels or refervoirs in which it is contained, and cannot remain longer in them on account of its fuperabundance, it breaks the membranous walls which contain it; it runs out fpontaneoufly, and appears on the outfide of the plant in the form of an excretion. Naturalifts and Chemifts avail themfelves of this circumftance, in order to collect and examine the products of thefe excretions as materials of the vegetables which afford them: frequently they even increafe their abundance, by enlarging the natural orifices through which thefe liquids flow out, or by making artificial orifices. In this manner are obtained the fap, the gums, the faccharine juice, manna, the volatile oils, the refins, caoutchouc, &c.

4. I confider as the fecond method, which I term *artificial mechanical analyfis*, the extraction

tion of the different fubftances which are obtained by breaking the cells or the vef-fels by various mechanical inftruments dif-ferently difpofed, according to the nature and texture of the plants, fuch as mortars, files, preffes, mills, &c. It is in this manner that we obtain the juices of plants, the mucilages, the fixed or volatile oils. This method, by which not only the liquids are feparated from the fo-lids, but alfo the different juices; oily, mucous, extractive, coloured, acid, faccharine, &c. and the different parenchymas, lamellated, fibrous, the grofs fecula, or the fine and amylaceous fe-cula, is one of the firft that are employed upon vegetables in order to obtain their different con-ftituent materials. It poffeffes the advantage of not changing the nature, or producing any alteration in the materials, and of affording them fuch as they are in the vegetables; it is much employed in the arts.

5. The analyfis by diftillation is, as I have al-ready obferved, the firft means which chemifts have employed; and for a long time it was the only one. The vegetables were firft diftilled with a gentle fire on the water-bath, in order to ex-tract the water of vegetation; and treated in boil-ing water to obtain the volatile oil. They were put into retorts of ftone-ware or iron, to which a receiver was adapted, in which were con-denfed the more or lefs faline phlegm, the oil or oils, the volatile falt, or the carbonate of ammonia, of thofe vegetables that afforded any,

any. Since the new diſcoveries, there has been added to it an apparatus for collecting the elaſtic fluids that are diſengaged at the ſame time with the preceding products: there remains a coal more or leſs denſe or rarefied, retaining or having loſt the form of the firſt vegetable ſubſtance which has been decompoſed. This is a really falſe or complicated analyſis, which gives, as I have already announced, ſubſtances formed by the action of the fire itſelf, which do not exiſt in the vegetable, and are manifeſtly compoſed by the influence of the caloric upon the firſt conſtituent matter of the vegetables. At preſent it is employed only for the purpoſe of comparing and oppoſing its effects with thoſe of the other analytic methods, and deducing from this compariſon of the liquids and ſolids of vegetables, the differences or analogies which theſe may preſent, either in the different ſpecies of plants, or in the different ſubſtances of each plant: alone, it would merit no confidence. Combined with other analyſes, this may afford great lights and very uſeful reſults, as will appear very clearly when we ſhall come to develop the nature of the influence which caloric exerts upon theſe organized beings, and upon the matters of which they are compoſed. The Pneumatic Chemiſtry has particularly ſerved to render this mode of analyſis uſeful.

6. When we burn plants or their products, it is ſufficiently known that all theſe ſubſtances are more or leſs combuſtible. It is not merely with

with the intention of obferving, (which however ought not to be neglected) the mode of their combuftibility, the form and the nature of their flame, their fmoke, or their odour,—but particularly in order to determine the quantity of coal which they are capable of yielding, the nature of the coal, denfe or rare, heavy or light, porous or folid, eafy or difficult to be burned, faline or not faline; to afcertain by incineration the proportion and the properties of the afhes which they yield, the quantity and the nature of the afhes which they contain, efpecially that of which alkali forms part, as alfo the metals or the metallic oxides which may be concealed in them. This *combuftion* is performed either in caft-iron veffels, in which the action of the fire is moderated by fmothering it, by which means we obtain coals or afhes not completely burned, and more or lefs oily, which were formerly termed fixed falts, prepared after the manner of Tachenius; or it is performed in the manner in which wood is burned in new furnaces, or on a clean hearth, upon a grate of earth or wrought iron. It is by this procefs that alkalis are obtained.

7. The *analyfis by means of water*, confifts in applying in general this liquid to vegetables, or to the different parts of plants, in order to feparate from them whatever foluble matter they contain. Under this point of view, all the immediate materials of thefe beings have been divided into two claffes; the one of fubftances

foluble

foluble in water; the other of infoluble fubftances: endeavours have been made to determine the relative proportion of thefe two kinds of fubftances. Water may be employed in five ways upon vegetable fubftances. Either they are left to foak in this liquid cold, which is termed *maceration*, or *cold infufion*. In the fecond, thefe fubftances are put, divided, and in the ftate of a more or lefs fine powder, into large quantities of water, in which they are agitated for a longer or fhorter time by means of agitators. This was the method of La Garaie, by which he obtained beautiful extracts, which he improperly called *effential falts*. According to a third procefs, hot or boiling water is poured upon the vegetables or their products, and fuffered to cool upon them: this is called *infufion*. A fourth confifts in heating water flowly and gently upon thefe bodies, and conftitutes digeftion, which draws out more of the matter than infufion, and extracts even more than maceration, in the method of La Garaie. Laftly, the fifth method is decoction; that is to fay, the operation in which water is made to boil upon the vegetable fubftance. This laft fpecies of action takes away much more matter from the plants than the four firft; but befides that, it fufes and carries away feveral without diffolving them; and alfo tears away others from the folid texture, and holds them only for a time fufpended; it changes the nature of the vegetable fubftances

to

to a certain degree, alters their compofition, deftroys the equilibrium of their principles, and does not afford the materials which the boiling water diffolves, without caufing them to experience a very remarkable alteration.

8. The analyfis of vegetables *by the acids and the alkalis* does not belong, as was formerly believed, folely to the menftrual analyfis, or the action of the fimple folvents. The acids and the alkalis, at leaft, unlefs very much diluted with water (for in this cafe they fcarcely act in any other manner than as folvents), produce a very great alteration in the materials of vegetables. When they are ftrong and concentrated, they fuddenly change the equilibrium of the compofition of thefe materials; they change their nature; and if we fhould afterwards take thefe materials thus changed for the true principles of vegetables, we fhould commit the fame error as was committed by the chemifts, when they believed that the products of the diftillation of vegetables exifted ready formed in them, previous to the action of the fire. Without explaining here how thefe fingular alterations of the vegetable fubftance produced by the acids and the alkalis are effected, which will be examined in detail in the order of facts that will follow the prefent,—it is fufficient to know that the modern chemifts have found, from the data of the pneumatic doctrine, the true caufe of thefe alterations, and that it has led them to a better knowledge of the vegetable

getable compounds, than could have been hoped for prior to the eſtabliſhment of this doctrine. Since this important diſcovery, the action of the acids and of the alkalis is no longer attended with obſcurity, and they have even become one of the moſt valuable and moſt uſeful inſtruments of analyſis that can be employed, in order to determine the vegetable compoſition with accuracy.

9. By applying the oils, alcohol, and ether, three ſubſtances themſelves of vegetable nature, to the analyſis of plants, it has been obſerved, almoſt ſince the commencement of the eighteenth century, that theſe ſubſtances have the property of diſſolving ſome of the materials of vegetables without acting upon the greater part of the reſt, and that they may thus ſerve to ſeparate theſe materials, and to indicate their relative proportion. They are ſometimes employed before the water, ſometimes after the action of this liquid; and according to the products obtained by the one or by the others, the relative quantity of the different principles which conſtitute them is compared. It has been ſeen, in the preceding article, that after having renounced the falſe inductions which they had drawn from the action of the fire, chemiſts had recourſe to that of water and of alcohol; they then conſidered only what each of theſe ſolvents took from the vegetables to be the real principles of the plants; what remained inſoluble both was conſidered as earth, as a *caput mortuum*, and they

committed

committed this ſecond error, becauſe they conſidered the vegetable analyſis only with relation to the art of healing, and becauſe they thought that this inſipid reſiduum was no longer capable of producing any action upon the animal economy. They did not conceive that ſome materials of the vegetables might eſcape the ſucceſſive action of theſe two ſolvents; and this was a ſecond error, which inſinuated itſelf into the reſults which they deduced from their firſt experiments; but theſe errors, which at preſent are well detected, no longer obſcure the ſcience, nor retard its progreſs.

The inductions which the action of theſe three ſpecies of chemical inſtruments affords, are much more exact than they formerly were, ſince their mode of acting has been better appreciated, as ſhall be ſhown in the following order. They are therefore juſtly ranked amongſt the moſt advantageous means of analyſis that can be applied to the knowledge of vegetables.

10. Finally, the eighth and laſt kind of analyſis, which I diſtinguiſh in the chemical examination of vegetables, is the *analyſis by fermentation*; that which nature employs in order gradually to decompoſe theſe organic bodies, when being deprived of life they no longer belong to the claſs of beings that are uſeful to her views, nor maintain their rank in the order of her economy. The chemiſts have drawn this means of analyſis from the very boſom of nature, and they have nothing more to do in

order to employ it for their purpofes, than to encompafs as it were the vegetable fubftances with circumftances and conditions which give rife to fermentation. It is by the play of the multiplied attractions between the different primitive principles of plants, that the motion of fermentation is produced; the equilibrium of their compofition is broken; their arrangement, their intimate difpofition, change more or lefs rapidly, and thence arife new products, the properties of which, when examined with attention, enable chemifts to conjecture what the fubftances were previous to their degeneration: it is, like every other chemical change, an equation of which fome parts have done nothing more than change their place, and paffed from one member to another, and which affords, when well underftood, a more or lefs fatisfactory folution of the problem which we wifh to refolve.

Article III.

Of the general Refults of the different Analyfes with refpect to the Vegetable Compofition.

1. AMONGST the eight diftinct fpecies of analyfis which I have enumerated and defcribed in the preceding article, we muft admit an effential diftinction, an important divifion into two

two genera; the one in fact confifts of immediate analyfes, which ferve to extract from vegetables the different compound fubftances which form their texture, without altering them or changing their nature; they afford, as products, what have been termed immediate or proximate principles of plants, the entire materials which are found ready formed and contained in their veffels and their refervoirs, fuch as their juices, their faps, their mucilages, their oils, their fecula, &c. Diffection, pounding, preffure, are efpecially the means of this analyfis. A flow fire, the application of water, of the oils, without the aid of a ftrong or long-continued heat, anfwer the fame purpofes; they feparate the compounded materials of the vegetables to which they are applied; and by thus infulating thefe different materials, they give, as their firft refult, the number and the relative proportion of thefe firft component parts, which are themfelves compounded; fo that they may already ferve to fhow the great difference which fubfifts between them and the foffils.

2. This however is nothing more than a firft point of the vegetable analyfis, and is far from being what chemifts either could or ought to have contented themfelves with. After having feparated and obtained the immediate materials of the vegetables, they foon difcovered that thefe materials themfelves are compounds much more complicated than thofe which are found in minerals; and the means which they have fuc-

 ceffively

ceſſively put in practice, in order to inveſtigate the compoſition of theſe immediate materials, belong to the ſecond genus of analyſes, the difference of which I ſhall proceed to ſhow. Theſe analyſes, no longer like the firſt, ſimple extractions, mere inſulations of the materials of which vegetables are immediately formed, they attack more or leſs profoundly theſe materials themſelves in their intimate compoſition: of this order are the more or leſs ardent action of fire, that of water aided by heat of combuſtion, of the acids, of the alkalis, and fermentation; whence it follows, that amongſt the eight ſpecies of analyſes there are ſome which can never be any other than immediate, or not altering analyſes, ſuch as the mechanical act of expreſſion, &c. others may either be the means of immediate extraction, when they are employed with moderation or little energy, as fire, water, the acids, &c. Laſtly, ſeveral of them never act otherwiſe than as altering and decompoſing means, ſuch as the action of the concentrated and powerful acids, combuſtion, fermentation.

3. It was by obſerving the effects of theſe deſtructive means, of this ſecond ſpecies of analyſis, and eſpecially the decompoſing power of fire, to which, for ſo great a length of time, they had almoſt excluſively recourſe, that chemiſts had conceived ideas, undoubtedly inaccurate and even erroneous, relative to the conſtituent principles of vegetables, but nevertheleſs ſuch as they were then able to conceive. Their inaccurate inſtruments,

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ments, and the profound ignorance in which they ſtill were, of the nature of the ſubſtances ſuſceptible of aſſuming the gaſeous form, all of which they took for air, had led them to imagine that vegetables were compoſed of fire, air, water, and earth, and theſe in fact were what they obtained, or believed they obtained, as the laſt reſult of the analyſis of vegetables. The gaſeous carbonic acid and hidrogen gas paſſed at that time for air; they neither knew how to collect them, nor how to determine their differences from the air ſtrictly ſo called; they ſuffered them to eſcape through the tubes and the open extremities of the apparatuſes; they were ſo many products which they neglected, or which they confounded with the fluid of the atmoſphere, in which they ſuffered them to be diſſipated. The liquids which they obtained, the water which formed their general baſe, appeared to them to be entirely contained in the vegetable matters; they were ignorant that this was a compound which might be formed in a direct way by the torture to which they ſubjected theſe ſubſtances, and that its elements, ſeparated from their ſtate of water, might exiſt merely as particular principles in the plants. The coal which they obſerved appeared to them to be earth, and they had no idea either of the indeſtructible nature of carbon, or of its properties, or of its exiſtence as a principle in organic bodies. Long did this opinion of the primitive compoſition of vegetables

getables by fire, air, water, and earth, reign in the ſchools, and it received the happy modification at which it has ſince arrived, only by the ſeries of diſcoveries, and of luminous ideas that have followed the eſtabliſhment of the pneumatic doctrine.

4. By means of theſe diſcoveries, modern chemiſts have found that the laſt term of vegetable decompoſition is almoſt always water and carbonic acid; that in order to obtain theſe laſt products of the analyſis of plants, nothing more is neceſſary than to deſtroy the equilibrium which kept their principles united; that all the oxigenated bodies, or thoſe capable of yielding oxigen, by adding that which was wanting, in order ſeparately to ſaturate the carbon and the hidrogen, contribute eſpecially to effect this total decompoſition; and that thus hidrogen, carbon, and oxigen, were found to be the cônſtituent principles of vegetables. The union of theſe three primitive bodies preſents in the ternary compounds a ſpecies of mixed combuſtible in part ſaturated with oxigen: theſe are a kind of oxides with binary radicals, in which the three principles which reciprocally ſaturate each other, are united by attractive forces which balance each other in ſuch a manner as to keep up amongſt themſelves the equilibrium and repoſe, which conſtitute the eſſence or the intimate nature of the vegetable compounds.

5. The difference of proportion between theſe three

three principles caufes thefe organic compounds to vary and differ from each other, and thence arifes the diverfity of what are called the immediate materials of vegetables, the mucilages, the acids, the oils, &c. but the attractions which keep thefe three fimple bodies united with each other, are capable of experiencing great and frequent alterations, of diminifhing and augmenting in fuch a manner, that the equilibrium which approaches them together is eafily broken: accordingly, thefe compounds, more complicated than thofe which are found in general in minerals, admitting between their principles, which are more numerous, and at the fame time lefs approaching to each other, a greater number, and confequently a greater variability of attractions, are much lefs permanent, and much more fubject to changes, than what are found in the foffils. Fire, which feparates the molecules of bodies, and diminifhes their attraction; water, which penetrates and tends to feparate them; fermentation, which equally tends to infulate them; all that can influence this complex compofition, the equilibrium of which is fo eafily deftroyed, quickly diffolves the link which keeps the principles in union with each other, varies their nature, modifies them inceffantly, but always at laft converts them into the two binary compounds, water and carbonic acid, which are conftantly the laft refults of all the chemical operations to which we fubject vegetables.

6. Thus

6. Thus we may conceive the multiplied changes which the vegetable compounds undergo between the two extreme terms of alteration which are produced in them by the different modes of analyſis to which they are ſubjected. From the moment when any agent, applied to a vegetable ſubſtance, begins to deſtroy the equilibrium of the attracting forces which exiſt between their three general conſtituent principles, the hidrogen, the carbon, and the oxigen, to that period at which this agent diſſolves them entirely, by uniting both the combuſtibles with the oxigen in particular, till it is reduced entirely into water and carbonic acid, the vegetable matter paſſes through a great number of intermediate degrees of compoſition, in which the carbon is more or leſs inſulated or diminiſhed; the hidrogen becomes equally either predominant or diminiſhed; the oxigen is detached with a portion of the hidrogen, or even of the carbon, or united in a fixed ſtate in a larger proportion than before with this ſubſtance. We alſo ſee it become coloured, ſoftened, fuſed, ſwelled, change its taſte, its ſolubility, become oleaginous or acid; in a word, it aſſumes a great number of modifications dependent upon the change of proportion and of equilibrium amongſt its firſt principles.

7. We muſt therefore conſider in general the vegetable ſubſtances as compounds, at leaſt triple, of carbon, hidrogen, and oxigen; as a kind of oxides, which vary from each other as they paſs out of the hand of Nature, in the

primitive

primitive proportion of their principles; very ſubject to alteration in this proportion itſelf, which, by this change of equilibrium, afford in the different ſtates which they are capable of aſſuming, important inductions to the chemiſt relative to their compoſition; which frequently permit us to appreciate more eſpecially this relative proportion between the different materials, which are compared with each other, upon which art operates, whether by diminiſhing or by augmenting this proportion of certain principles, ſo as to modify them, and cauſe them to paſs from one ſtate to another, and thus to ſeize in ſome meaſure, through theſe tranſitions, the modifications of the compoſition of the ſubſtances which experience it. Here I have only to announce the generality of theſe principles; the details and the facts in ſome meaſure ſpecific, which are deducible from them, will be exhibited in the articles of the ſubſequent orders.

8. It is to the ſame conſideration concerning the general nature of the vegetable compounds, that we have to refer the impoſſibility which chemiſts have hitherto found, of forming in a direct way a ſubſtance analogous to that which the plants afford. We have ſeen in ſome of the preceding ſections, and eſpecially in the ſecond, that it is poſſible to unite ſulphur, phoſphorus, and carbon with hidrogen; that this latter combination exiſts particularly in carbonated hidrogen gas, and in the vegetable coals; but when we attempt to add to this binary combuſtible the

oxigen which would be neceffary, in order to make it approach to a vegetable compound, either the union is not poffible, or in proportion as it is effected, the carbon and the hidrogen feparate the one from the other, and combine feparately with the oxigen; and if we reflect for a moment, we find that all the phenomena of vegetable analyfis confift in this. The art of chemiftry is permitted to infulate, and to deftroy the union of the principles in a vegetable compound. As foon as it acts upon this compound, it firft deftroys its equilibrium; and however flight its action may be, it tends to change the nature of its compofition, to convert it into another, to modify it by entirely deftroying a portion of it: but it can never augment a vegetable fubftance, at the fame time leaving it fuch as it is; its means, its inftruments are too violent, too penetrating, too active; and to nature alone is referved the power of creating, reproducing, in a direct way forming the firft elements or primitive matters of the vegetable compounds. This laft fubject, which is of great importance, will be fufficiently developed in the fubfequent article.

Article IV.

Of the Refults of Vegetable Analyfis in general, applicable to the natural Formation of the Materials of Vegetables during their Life, and to their Alteration after their Death.

1. SINCE all the moft exact analyfes have fhown that the vegetable fubftances are formed, in their firft principles, of carbon, hidrogen, and oxigen, to which are added, but only in fome cafes, and not as indifpenfable acceffaries, azote, fulphur, phofphorus, &c. it is very evident that the problem of the natural formation of thefe compounds confifts in knowing whence the vegetables derive thefe primitive fubftances, and how they appropriate them to themfelves, and thus combine them three and three. This problem in fact comprifes the whole of vegetable phyfics; and it is not in thefe firft confiderations with which I am here occupied in the articles that form a fort of introduction, or preliminary difcourfe, to the analyfis of plants, that I can, or even ought to difcufs it in its full extent. I here intend only to point out that intimate relation which fubfifts between the generalities even of the knowledge we have relative to the vegetable analyfis, and the facts which

which appertain to vegetation: this is the only object to which I can now attend.

2. What I have said above concerning the impracticability of composing a vegetable substance by chemical means, as yet, though we are not denied the hope of being hereafter able to do it, and though the same has perhaps already been done without our being aware of it, especially with respect to mucilage, the most simple perhaps of the materials produced by the organized bodies,—what I have said necessarily refers to the creative or plastic power which vegetables enjoy during their life. The very act of vegetation consists in forming for their own development, for the extension and the nutrition of their parts, the different immediate materials which constitute them. After having drawn in by their roots and by their pores, which are always open, caloric, air, water, carbonic acid, carbon itself in a state of division, which is furnished to them by the soil charged with natural or artificial manures; the vascular, and especially the utricular organs, which every where form their texture, appropriate to themselves these nutritive principles, recompound them, and effect with them, by a succession of chemical phenomena or forces, the ternary combination, or compositions, which constitute their liquids and their solids, or their immediate materials.

3. It is sufficient in this place, if we well understand that the formation of the vegetable com-

pounds

pounds is the product of the chemical attractions, which exert themſelves in the organic inſtruments of the plants; and conſider whatever takes place in vegetation, in the chemical vegetable conſtitution, as a ſeries of operations, of natural analyſes and ſyntheſes, the determination of which, though eaſy to be conceived in general when the nature of theſe organic compounds is underſtood, muſt depend immediately upon the proceſſes we have deſcribed in explaining the nature of theſe ſame compounds. No doubt can remain reſpecting the influence which the chemical analyſis of vegetables muſt have in the appreciation of the phenomena of vegetable life; and when we ſhall have informed ourſelves in detail with all the properties of thoſe beings, we ſhall ſee what great ſervices chemiſtry has already rendered, and eſpecially how many are ſtill to be expected, from the application of the modern or pneumatic chemiſtry to the philoſophy of plants.

4. The expoſition of the general nature of vegetable compounds is no leſs important for underſtanding that of the different and numerous alterations which they are capable of experiencing after their death. In general, the totality of theſe alterations is to be conſidered as the neceſſary conſequence of their complicated compoſition, and of the play of the multiplied attractions which re-act between the different conſtituent and primitive principles which form them by their union. This equilibrium,

librium, which keeps their elements united, is ſo eaſily diſturbed, and this perturbation is ordained in ſuch a manner by nature, it enters ſo immediately into the plan of her economy, that it is the courſe which ſhe cauſes the vegetable ſubſtances to take, in order to make them reſtore in ſome meaſure the portion of matter which ſhe had lent for their organization, and return it to the common receptacle of its perpetual circulation and employment. This character of deſtructibility depending, as I have ſhown, upon the nature of their compoſition itſelf, is one of the greateſt differences that can be eſtabliſhed between the vegetable matters and the foſſil ſubſtances. The latter always remain in the ſame ſtate, at leaſt as far as relate to themſelves, and are alterable only by external cauſes and accidents; whilſt the former contain in themſelves, and by reaſon of the complicated attractions of their multiplied component parts, an intimate principle of alteration, and of ſpontaneous deſtruction, dependent upon their order of compoſition, which prevents their remaining for a long time in the ſame ſtate.

5. The ſame general data, relative to the compoſition of the primary materials, alſo diffuſe the greateſt light over the arts which are occupied with theſe matters. It has been ſeen that all the ſpecies of vegetable analyſis may be conſidered as belonging to two genera; the one in fact does nothing more than extract, without altering,

tering, the immediate materials of vegetables; the others modify, change, alter, and decompoſe them more or leſs powerfully, either at the very moment in which they are extracted from the plants, or a longer or ſhorter time after they have been extracted. The arts which are exerciſed upon vegetable ſubſtances, if we except thoſe which only change their form or external dimenſion, have equally the double object, either of ſeparating ſome particular matters from vegetables, in order to obtain them inſulated and more or leſs pure, or to convert theſe matters into new products, modified and appropriated to the different uſes of ſociety. Now in both caſes, they are referrible either to ſimple extraction, or to the more or leſs advanced decompoſition of the immediate materials of the vegetables. This general view is ſufficient for the preſent, to ſhow the relation which ſubſiſts between the chemical knowledge that has been acquired reſpecting plants, and the arts whoſe object it is to employ them for the benefit and proſperity of men united in the ſtate of ſociety. The articles compriſed in the ſubſequent orders will give much more perſpicuity and fulneſs to theſe firſt notions.

Third Order of Facts relative to the Vegetable Compounds.

Of the Chemical and Characteristic Properties of Vegetable Subſtances in general.

ARTICLE I.

General Obſervations concerning theſe Properties.

1. THE details which I have given in the preceding order relate only to the compoſition of the vegetable ſubſtances in general. They ſhow in what this compoſition conſiſts; they exhibit the notions that have been adopted, and the facts that have been aſcertained by the lateſt diſcoveries of ſcience relative to the nature of the vegetable compounds. After they have been well conſidered and underſtood, they muſt naturally lead us to the inveſtigation of the chemical properties which characterize theſe compounds, the expoſition of which they render more eaſy, and their theory more luminous.

2. I call thoſe the chemical properties of vegetable compounds, which, ſhown in the manner in which thoſe compounds, when deprived of their life, or ſeparated from the living vegetable are affected by the different re-agents, to the contact of which they are expoſed, the changes they experience

experience, and the new refults which they afford. It muft undoubtedly be here expected that great differences will be found between the organic matters, and the mineral or foffil fubftances. In general the firft, being more complicated in their compofition, are infinitely more changeable by the action of thefe bodies, and the alterations which take place in them muft be more multiplied, more difficult to be underftood or well explained, than thofe that have been indicated in the hiftory of all the preceding fubftances.

3. As this new part of the fcience has not yet been treated and developed in a fufficiently extenfive manner in moft of the works of chemiftry, and as in general the vegetable analyfis has not yet received, in the elementary books, that extenfion of which it is fufceptible, and which alone is capable of affording an adequate notion of its prefent ftate, as well as of accelerating its progrefs, I have thought it incumbent upon me to treat of the properties of vegetable compounds in general, before fpeaking of their immediate materials in particular. By this means the hiftory of the latter will become much more perfpicuous, and will require no additional details, which would occafion a great number of repetitions.

4. Amongft the alterations which conftitute the effects of the different agents upon the vegetable compounds, and which determine the chemical properties of the latter, though they all

tend to their decompofition, and at laft even produce it completely, there are feveral which are only a kind of converfion of the one of thefe matters into the other; and this is one of the characters moft intimately connected with their nature. Confidering them all under this point of view, we fhould be led to fay, that there is only one fingle vegetable fubftance in general, fufceptible of a number of modifications, of fucceffive tranfitions from its firft ftate, or moft fimple compofition, to its complete decompofition. Thus we are induced to believe that mucilage is the firft vegetable compound, that which is the leaft remote from the foffils by its fimplicity, and that the acetous acid is in this genus the laft term of the compofition; fo that, when we fhall well underftand the fucceffive alterations or modifications which the vegetable matter is capable of undergoing, we fhall be able to arrange in a natural order all the immediate materials of vegetables, which are really nothing more than co-ordinate and neceffary tranfitions of the vegetable compound from one ftate to another, and of which it is neceffary only to determine accurately the relations and natural arrangement.

5. Under this head of remarkable permutations, it is that we ought to arrange all the changes of which the vegetable fubftances are fufceptible, or all the chemical properties which characterize them, and are only the different effects of thofe changes. Hence it happens, that

that however different the agents or the inſtruments may be which muſt be employed in order to determine theſe properties, they all reſemble each other in their ultimate or more energetic action; or at leaſt there ſubſiſts between them, in the mode of their effects, relations, or analogies, which I ſhall not neglect to point out. Thus all the re-agents proper for changing the nature of vegetable ſubſtances modify them at firſt, cauſe them to aſſume different ſtates, which ſeparate them into different compounds leſs complicated than they were at firſt, and all equally conclude with reducing them, as the laſt reſult, into water and carbonic acid.

6. But though this analogy, ſo illuſtrative of the effects of the re-agents, is connected with the very eſſence of the vegetable compound, though I obſerve that I here conſider the whole maſs of the materials of vegetables only as a ſingle compound, as a kind of matter produced by the work of vegetation, I am obliged, in order to enunciate all the modifications which this ſubſtance is capable of experiencing from the different agents, and which conſtitute its real chemical properties, to diſtinguiſh theſe into as many particular effects as there are agents or inſtruments capable of enabling us well to determine theſe properties. This method will have the advantage of ſuffering nothing of importance to eſcape, and of preſenting the regular ſeries of all the modifications which the vegetable matter can and actually does aſſume.

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I diſtinguiſh all the chemical properties of the vegetable ſubſtance in general, conſidered here as a ſingle genus of compounds, into ſeven phenomena, according to the number of agents which exert their energy upon this matter. Theſe ſeven phenomena ſhall have the titles of actions of fire, of air, of water, of the alkalis, of the acids, of the ſalts, and of the oxides and metallic ſolutions. By conſidering the whole in ſucceſſion, we ſhall not only aſcertain the degree of perfection which the ſcience has already acquired, but alſo the elevation to which it may ſtill hope to arrive, and the perfection which it ought to attain.

Article II.

Of the Chemical Properties of Vegetable Subſtances treated by Caloric.

1. BEFORE I here determine with preciſion what are the chemical changes which caloric produces in the vegetable compound in general, I muſt diſtinguiſh thoſe which it cauſes it to to undergo, according to the different proportions of its accumulation, or according to the degrees of temperature. Four phenomena preſent themſelves here, and ought to be ſucceſſively examined; the one is inſpiſſation or deſiccation; the other anſwers to what is termed diſtillation on the water bath; the third is coc-

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tion or baking; the fourth the total diffolution of the principles, whether in clofe or in open veffels. The three firft are only partial decompofitions fimple changes, or modifications; the laft is the complete decompofition.

2. No one is ignorant, that however mild the temperature may be, and however moderate or flight the quantity of heat which is accumulated in a vegetable fubftance, whether liquid or folid, its nature is gradually changed, indeed in a longer or fhorter fpace of time, and in a more or lefs feeble degree. Thus, by the heat of a ftove, the vegetable liquids are thickened, their colour grows deeper, they affume vifcidity, confiftence, and even a perfectly folid ftate. Thus the juices become concrete and coloured; as that of the heads of poppies forms opium; from the white and very liquid ftate in which it formerly was, it becomes reddifh-brown and folid. The fame happens with the juice of aloes and of euphorbium. It is not, however, as has been believed, the mere evaporation of the water which produces this effect; and it is not a fimple infpiffation which takes place even without the contact of the air. Some of the principles have already re-acted upon each other; already has the equilibrium of the vegetable compofition undergone fome derangements, and a fmall portion of the hidrogen having efcaped with the water, the matter is a little more carbonated, and confequently a little more coloured than it was before.

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3. The ſolid and freſh parts of vegetables, when we wiſh to dry them, to deprive them of the water of their green ſtate, which would produce an alteration in them, and to preſerve them afterwards without alteration in this ſtate of dryneſs, undergo ſomething ſimilar, whether we leave their deſiccation to be effected by the rays of the ſun in a convenient ſeaſon and weather, or effect it by the artificial heat of ſtoves. The following are the changes that take place in the delicate texture of the flowers, the more ſolid texture of the leaves, the ſtill more ſolid ſubſtance of the bark, the ſtalks or the roots. Their colour changes, or if it be preſerved in the moſt permanent, it becomes deeper, and is ſenſibly altered; their organization is deſtroyed; in proportion as their water is diſſipated, a more or leſs perceptible odorous matter eſcapes from them in ſtreams that are inviſible, but very diſcoverable; animals avoid or ſeek it, according to its nature; and the air is frequently altered by it. If the deſiccation be too violent or too long continued, the vegetable matter not only becomes inodorous, brown or yellow, dry and brittle, and frequently little or not at all ſapid, but after examining it, we find it almoſt burned, and very much altered; ſometimes even it is no longer fit for the purpoſes for which it was deſtined.

4. Diſtillation on the water bath produces a change very different from that which has hitherto been attributed to it: undoubtedly it diſen-

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gages the water that exifts ready formed in the vegetables, and reduces it to the ftate of vapour; but it is not only this water contained and exifting ready formed which is raifed, but a certain portion is alfo formed by the tendency which the hidrogen has to infulate itfelf with the oxigen. The carbon, which foon predominates, gives a fallow or light-brown colour to the vegetable fubftance. It is true that the gentle temperature, which this mode of treatment produces, affords only a very fmall quantity of this product; but this is fufficient to induce a fenfible change in the organic matter, which, after it has experienced it, is no longer exactly the fame as it was before. Together with this water, partly contained, and partly formed by the diftillation on the water bath, an odorous matter is fublimed, which was long confidered at a particular vegetable principle, and defignated by the names of *fpiritus rector* or *aroma*; but I have proved by particular inveftigations, of which I fhall give an account in the article concerning vegetable tranfpiration, that there exifts no aromatic principle properly fo called; that every fubftance, whatever it may be, has a determinate odour when it is volatilized; that whatever efcapes in vapour from the fubftances which are fubjected to the action of the fire, prefents itfelf with this odorous character; that it is moft frequently volatile oil, diffolved in water, which conftitutes it, but that it

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may alſo be a ſmall quantity of extractive matter, mucilage, or ſome gaſeous ſubſtance.

5. I have diſtinguiſhed, as a particular phenomenon or product of fire, the coction or baking of vegetables, as the chemiſts have not yet paid ſufficient attention to this ſingular change, which however is one of the moſt known and moſt uſeful to mankind. It is known that when we expoſe to a dry heat continued for a longer or ſhorter ſpace of time, either immediately upon the fire of the grate, or in the hot aſhes, a vegetable ſubſtance, ſolid and generally a little ſucculent, a pulpy, parenchymatous fruit, a ſtalk, or a tuberous root; theſe ſubſtances, penetrated with caloric, grow tender, ſoft, more eaſy to be bruiſed than they were before, acquire a mild and ſometimes ſaccharine taſte, inſtead of the inſipid or even auſtere flavour which they had at firſt, and are afterwards much more agreeable, as an aliment, to man, and even to ſeveral animals, whilſt at the ſame time they become more eaſy of digeſtion. Is it not therefore evident, even to one who has leaſt ſtudied this part of natural philoſophy, that a remarkable change muſt take place in the vegetable ſubſtance thus baked and become pulpy, ſoft, and ſweet; that there has been formed in it water and ſaccharine matter by a new combination of its principles, and that coction is one of thoſe tranſitions of compoſition which approach greatly to the nature of maturation or of germination?

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As to the roafting of fome other dry vegetable fubftances, an operation which is alfo fometimes called baking, fuch as that of the farinaceous grains, chefnuts, farina, fecula, bread, it is very evident that the reddifh colour, the brittle property, and the fomewhat acrid tafte which thefe fubftances acquire, are the product of a more profound and more violent alteration which they undergo, and which in fome meafure refembles what takes place at the commencement of deftructive diftillation with the naked fire of which I am about to fpeak. The roafting of coffee is the firft term of alteration which a dry vegetable matter can undergo, previous to its total decompofition, in the economical operations to which vegetables in common ufe are fubjected.

6. When we expofe a dry vegetable fubftance to a heat above that of boiling water, in clofe veffels, in an apparatus compofed of a retort of ftone-ware, of iron, or of hard glafs, and coated with lute in order that it may be able to refift the action of the fire, a receiver of glafs, provided with a tube of fafety, and terminated by a tube immerfed under a glafs jar filled with water; and if we apply to this apparatus a graduated heat till the bottom of the retort has become red hot; the vegetable matter will be then entirely decompofed, by its infulated principles acting upon one another; we obtain a fucceffion of gafeous, liquid or even folid products, which did not exift in the fubftance, and there remains

mains a coal retaining the primitive form, and even organization, if the ſubſtance was ſolid, or more voluminous and differently configurated if the matter was fuſible. Though theſe products differ more or leſs from each other, accord- to the diverſity of the vegetable ſubſtances which furniſh them, and though it is neceſſary well to diſtinguiſh the products of the gums, for example, from thoſe of the oils, the extracts, the woods, as I ſhall ſhow in the following order of this ſection, there exiſts nevertheleſs, even in the midſt of this diverſity, an identic generality of alteration, which depends upon the nature of vegetable compoſition, and ought to be here conſidered in its aggregate as a characteriſtic property of this genus of compounds. The manner in which the pneumatic doctrine has arrived at the knowledge of the nature and cauſe of this attraction is one of the moſt beautiful reſults of the revolution of chemiſtry, and one of the moſt ingenious theories which at the preſent day we poſſeſs. It explains all that was obſcure and uncertain in the operations of the chemiſts: it ſhows how they were led into error; how the new materials that were obtained were formed; how, even from the formation itſelf of theſe materials, we may derive a ſufficiently exact knowledge of the nature and primitive compoſition of vegetable ſubſtances.

7. In order to comprehend the remarkable changes produced upon vegetable ſubſtances

ftances by the action of a violent fire, it is neceffary we fhould recollect that thefe fubftances are compofed of three primitive principles, hidrogen, carbon, and oxigen, maintaining themfelves in their equilibrium of ternary combination at the ordinary temperature, on account of the equality of attraction which exifts between them. But when the temperature is raifed, when the caloric, penetrating the mafs of this compound, removes the molecules farther from each other, then the attraction which keeps them united is weakened, and they tend to feparate from one another; and if the heat be but a little fuperior to that of boiling water, the hidrogen and oxigen feparated in part from the carbon combine together and form water, which is difengaged; a portion of the hidrogen combines with a certain quantity of carbon, and forms an oily compound, which is volatilized: thus the phlegm and the oil, the two firft products of a vegetable fubftance diftilled by a degree of heat fuperior to that of boiling water, were not contained ready formed in the fubftance, but are to be confidered as productions of the fire. At the fame time when thefe two compounds are formed, feveral vegetable acids are alfo formed, which likewife did not exift in the vegetable fubftance, but are owing to the combination of a portion of carbon, of hidrogen, and of oxigen in particular proportions; the pyromucous and the pyroligneous acids are the beft known of thefe empyreumatic acids,

acids, though there is reafon to believe that there are feveral others hitherto unknown, which are compofed in this manner by the action of the force. In proportion as thefe new combinations are effected at the temperature which I have indicated, carbon is left behind, which not being able to enter into thefe combinations on account of its fuperabundance with relation to the hidrogen and oxigen, retains fome of the fixed fubftances, efpecially of the falts and earths contained in the fame organic fubftance, abforbs a portion of oxigen, and forms a coal which remains in the retort.

8. But when we apply to the vegetable fubftances a heat much fuperior to that of boiling water, and fuch as to render the retort red hot; water is then no longer formed; becaufe at this temperature the carbon having a ftronger attraction for the oxigen than the hidrogen has, carbonic acid is fooner produced; and the portion of water which was formed previous to the application of this violent heat is decompofed during this fecond period by the red-hot carbon, and forms carbonic acid: the hidrogen being then fet at liberty is difengaged, fufed by the caloric into elaftic fluid, in the ftate of carbonated hidrogen gas; oil likewife is then no longer formed, and that which had been formed and had remained in the vegetable fubftance is decompofed. This is what happens at the end of the diftillation of vegetables in the retort, and is the reafon why

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at this period, the temperature being much elevated, a confiderable fwelling takes place in fuch of thefe fubftances as are fufible. The abundant difengagement of carbonic acid and carbonated hidrogen gas then raifes the whole mafs, and fills the receivers with a grey fmoke, on account of the portion of carbon which the latter very hot gas carries with it, and of which it begins to depofit a portion in the upper part of the apparatus, from the firft degree of refrigeration which it then experiences. The action of the fire does not ceafe till there is no longer any hidrogen or oxigen in the fubftance fubjected to diftillation, and then the coal which is its refiduum remains alone and without any volatile matter.

9. According to the rapidity and the force of the heat which is employed in this operation, we obtain at pleafure either the one or the other of the two kinds of phenomena and products, which, in fact, depend upon the difference of temperature with which this diftillation of a vegetable fubftance is effected. The firft kind of phenomenon is characterized by the formation of water, of oil and of the liquid acids; the fecond by the difengagement of carbonic acid gas and carbonated hidrogen gas. We have it in our power to decompofe or alter the organic matter in either manner, to change it into either of the new compounds: and thus by the diverfity of alteration which is in our power,

it is very well ſhown in what the action of fire upon vegetables really conſiſts.

10. I do not here ſpeak of that product of diſtillation by naked fire, or the violent decompoſition, effected by heat, which is obtained much more rarely and much leſs conſtantly than the preceding, from only ſome vegetable ſubſtances, becauſe it is only a kind of acceſſary of the firſt, and becauſe this product, which is conſtant in the diſtillation of animal ſubſtances, is formed only in the diſtillation of thoſe vegetable ſubſtances, which approach to the nature of the former: this product is ammonia. It is obſerved only in ſuch of theſe ſubſtances as contain azote amongſt their principles, and which, by this addition, become complicated in ſuch a manner, that they have long been termed *vegeto-animal* ſubſtances by the chemiſts; of theſe we ſhall ſpeak in the following ſection:

Article III.

Of the chemical properties of vegetable ſubſtances treated by the air.

1. IT was impoſſible for chemiſts to comprehend or explain the effects of the air upon the vegetable ſubſtances that are expoſed to it, after having ceaſed to live or vegetate, at the time when they knew neither the conſtitution of the air nor the general compoſition of theſe ſubſtances.

ſtances. Though they were able to obſerve ſome of the alterations which they undergo, eſpecially the moſt prominent and remarkable, they were unable either to aſcertain exactly in what they conſiſted, namely the real changes that had taken place in the compoſition of theſe ſubſtances, or to determine the part which the contact of the air had in them. They ſaw that the vegetable ſubſtances became coloured, dried, and withered, or were decompoſed, when theſe effects were ſufficiently marked to be very manifeſt and diſtinguiſhable; but they neither knew whether the ſame phenomena took place in cloſe veſſels, nor why or how the atmoſphere contributed to their production. Moreover, when we compare the few notions which the Ancient Chemiſts poſſeſſed relative to this ſubject, even concerning the moſt violent of theſe alterations, we ſoon ſee that moſt of the facts which concern them eſcaped their notice, and that it was even very natural that they ſhould hardly pay any attention to them: accordingly, prior to the eſtabliſhment of the pneumatic doctrine, before the data of Lavoiſier and Citizen Berthollet, nothing had been ſaid concerning the properties of the vegetable ſubſtances dependant upon the air. The elementary books, written even ſince that period, have treated too ſuperficially concerning this ſubject.

2. In order that I may omit nothing that belongs to theſe chemical properties derived from the action of the air upon the vegetable ſub-

ſubſtances, I ſhall deſcribe them, or rather I ſhall announce them here as forming ſix very diſtinct phenomena.

a The object of the firſt will be the abſorption of a principle of the air by theſe ſubſtances.

b. That of the ſecond, the precipitation and the concretion in the vegetable liquids which follow this abſorption of one of the principles of the atmoſphere.

c. The third will comprehend the coloration which theſe ſubſtances undergo.

d. The fourth, the kind of combuſtion to which we may refer this chemical property in general.

e. The ſubject of the fifth phenomenon will be the change which the air itſelf experiences from the action of the vegetable ſubſtances, in proportion as its contact cauſes them to experience the four firſt.

f. Laſtly, in the ſixth and laſt phenomenon, I ſhall rank that kind of decompoſition, more or leſs ſlow, which vegetable ſubſtances undergo by the contact of the atmoſpherical air.

This diviſion into ſix phenomena, by particularly fixing the attention of chemiſts upon each ſpecies of alteration which the air produces in the vegetable compounds, will be attended with the particular advantage of omitting nothing which is eſſential to be known reſpecting this genus of chemical properties; and though this department is not ſo far advanced as were to be wiſhed, wifhed, it will at leaft appear very proper for exciting the attention of the learned, and engaging them to ftudy, more than they have done hitherto, this kind of action, which deferves to occupy them, and form the object of more profound refearches than thofe to which it has yet given occafion.

3. It is a fact well known in the immenfe feries of pneumatic experiments which have been made during more than twenty years paft, that when we expofe a fubftance, and efpecially a vegetable liquid to the contact of the air, in a veffel which ferves exactly to meafure its volume, and alfo enables us to examine the alteration which the air has experienced, a more or lefs fenfible abforption takes place, or diminution of volume more or lefs diftinguifhable. When we examine, by eudiometric means, what part of the air has been abforbed, we find that it is oxigen gas, and that what remains of the air is more or lefs mephitic, more or lefs furcharged with azotic gas. Almoft all the vegetable liquids poffefs this property; but it is more remarkable in fome, fuch as the faps, the juices of herbs, the oils, the extracts diffolved in water, &c. fome vegetable liquids effect it even in fo powerful a manner, that they become very frothy by agitation. We muft take care not to confound thofe which become frothy in confequence of a gas which is difengaged from them, with thofe that become covered with a frothy fcum in confequence of the abforption. The

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firſt preſent this phenomenon without the contact of the air; the ſecond produce a vacuum in veſſels partly full, in which theſe liquids are agitated; it is probable even that we may hereafter find ſome vegetable ſubſtances that have a ſufficient avidity for the atmoſpheric oxigen to act eudiometrically upon the air.

4. In proportion as the liquid or diſſolved vegetable ſubſtances that are expoſed to the air abſorb oxigen from it, they become turbid, depoſit flakes which are precipitated, or become covered with concrete plates of which they did not previouſly exhibit the ſlighteſt trace. In this manner the oils concrete at their ſurface, or even in their interior part, by the abſorption of the oxigen, as has been diſcovered and well proved by Citizen Berthollet. In this manner, I have diſcovered that the expreſſed and clarified juices, when expoſed for ſome time to the air, become filled with concrete flakes which ſwim in their liquor, and which are depoſited after ſome hours; which does not happen to them in well-dreſſed and full veſſels; there are even ſome decoctions of dry vegetable ſubſtances, of woods, barks, and roots, which become turbid by the contact of the air, and which afterwards depoſit powders, or thick and ropy inſoluble maſſes, or irregular flakes. I have particularly obſerved that much of this matter was formed in the decoctions of Peruvian bark that were made to boil for a long time, and that they thus loſt the greater part of their vir-

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tues. It is therefore one of the well characterized chemical properties of vegetable ſubſtances, to be rendered in this manner concrete by the atmoſpherical oxigen which they abſorb, and to form oxigenated products, which precipitate themſelves from the liquids, and which have become inſoluble, or much leſs ſoluble than they were before.

5. The coloration of vegetables by the air is one of the moſt known and moſt conſtant phenomena; every one indeed knows that the white roots of ſalſifis, the white petioles of the Spaniſh thiſtle, beet, the huſks of nuts, the pulp of pippin-fruits, &c. when expoſed for ſome time to the air, aſſume yellow, brown, and even black colours, againſt which, attempts are even made to guard them, in order to preſerve that whiteneſs which is agreeable in alimentary ſubſtances. The colours which ſome kinds of white wines ſo rapidly aſſume in bottles, alſo afford a frequent proof of the exiſtence of this coloration; to this we may add the coloration of the ſkins of fruits, that of the leaves which acquire a deep green colour, of the barks which become brown, of the flowers which do not acquire their tints till after they are blown, and which, having been almoſt colourleſs in the calicine covering in which they were folded up, become adorned with all their colours when they open in the atmoſphere; but theſe phenomena being complicated with thoſe of vegetation, during which they take place, I

ought here to mention thofe only which belong to vegetable fubftances when deprived of life. I have ftudied with attention, and defcribed in "Annales de Chimie, tome V," the influence of the atmofpherical oxigen gas upon the coloration of vegetables, Having been ftruck with the beautiful blue colour which indigo affumes in the air, after having been taken green out of the dyeing-vats, with the blacknefs which fubftances impregnated with galls and which ink affume in the air, with the brilliant or deep colours which all the cryptogamic plants exhibit when they are altered or decompofed in the atmofphere, with all that takes place in calico-printing and dyeing, with refpect to the ufe which is made of vegetable fubftances in thofe arts, as well as with the phenonomena of coloration which I have juft quoted in the different parts of living plants, I particularly directed my refearches to the infufions and decoctions, and efpecially thofe of the barks of the yellow or red woods. I obferved, that when expofed to the air, they become covered with a granulated pellicle, which paffed fucceffively through the colours of brown-black, brown-purple, chefnut-red, orange and yellow; that in the latter ftate, the coloration by the air was fixed, and becomes little or not at all alterable; that previous to the coloration in yellow or fawn, which is the laft term, the vegetable matter paffed through different tinges which remained ftationary and fixed, according to the different

ferent proportions of oxigen. I have proved that thefe fhades were really owing to the fixation of oxigen, by imitating them by the addition of different proportions of oxigenated muriatic acid to thefe decoctions: I particularly obtained from the decoction of Peruvian bark five or fix colours more beautiful, more rich, and efpecially more folid than the ordinary lakes, of which I fhall fpeak hereafter. From the whole of my labours upon this fubject, I have drawn the following general refults: *a.* Oxigen combined with the vegetable fubftances changes their colour; *b.* the proportions of this principle produce variations in the fhades; *c.* thefe fhades follow a kind of degradation from the deepeft to the lighteft colour; *d.* the vegetable reds, purples, violets, chefnuts, blues, owe their tinges to different proportions of oxigen; *e.* the complete faturation with this principle produces the yellow, or the fawn, which is the moft durable of all the vegetable colours; *f.* the change of colour by the abforption of the oxigen is followed by a change of nature, and the vegetable fubftances which experience it become lefs foluble in water, and more or lefs oily or refinous.

6. Befides the concretion and coloration which are obferved in vegetable fubftances expofed to the air, and which are owing to the fixation of a more or lefs confiderable proportion of atmofpheric oxigen; thefe fubftances undergo a flow combuftion and an alteration in their compofition,

compofition, which has been very well determined by the experiments of Citizen Berthollet. At the low temperatures to which vegetable fubftances are expofed in this kind of experiments, hidrogen has more attraction for the oxigen than carbon has: accordingly, the hidrogen, a principle of thefe fubftances, tends to difengage itfelf from them, and is actually feparated, molecule after molecule, in fuch a manner as to burn by degrees with the atmofpherical oxigen, and to form water: hence the drops of this liquid, which appear upon the fides of the receivers, in which we thus expofe in confiderable volumes of air the fliced fruits and the chips of wood, whofe alterability by the air we wifh to determine. In proportion as this hidrogen exhales and burns flowly in the air, the quantity of carbon, which forms one of their principles, augments and colours the vegetable fubftance the more fenfibly, the more confiderable this augmentation is. This is the manner in which Citizen Berthollet has explained the brown colour which woods affume by their expofure to the air. This effect is well known in the wood of the oak, and in that of the walnut-tree; it is ftill more remarkable in mahogany, which from a delicate rofe or pale flefh-colour paffes to a blackifh brown: it is known that this alteration, the product of a flow combuftion of the hidrogen and feparation of the carbon, takes place only at the furface, fince whenever we remove or uncover this furface, we find a much lefs deep colour, which indeed muft in its turn affume the above-mentioned caft, when it fhall have been left for fome time expofed to the air.

7. It is alfo of effential confequence, in order to appreciate what happens to vegetable matters during the changes which they experience by the contact of the air, to determine at the fame time the change which the air itfelf experiences, and this determination muft equally lead to the knowledge of what happens in thefe fubftances, or the real nature of their chemical properties. Air, which has been left for fome time in contact with the vegetable fubftances, is found deprived of a part of its oxigen, which is determined by the eudiometric proceffes. It even occurs pretty often in the circumftances of common life, that it is not neceffary to have recourfe to eudiometrical proceffes in order to perceive this alteration which air experiences from the action of vegetables. Clofe places, in which thefe fubftances are accumulated, conftantly become dangerous to animals; perfons have often been known to have been ftruck with afphyxia in confined or clofe places, where a large quantity of flowers, leaves, or ftalks were drying, or where large heaps of hay or fruit were accumulated. Befides the odorant matter proceeding from the volatilization of fome of the principles of the plants, or of their parts, the frequently pernicious alteration of the air fhows itfelf here under three afpects, or produced by

by three caufes acting at the fame time. The one is the abforption of a portion of its oxigen, of which I have already fpoken; the other confifts in the combuftion of the hidrogen, which I have developed in the preceding number; and the third, of which I muft alfo fpeak a word here, muft be referred to the formation of a certain quantity of carbonic acid gas. This, the influence and the quantity of which may be determined by the fixed alkalis and lime-water, fhows that hidrogen is not the only combuftible principle difengaged from the vegetable fubftances by their expofure to the air; that whilft it exhales from thefe fubftances it carries with it a fmall quantity of carbon, which being extremely divided by this aëriform folution, burns, either at the fame time as the hidrogen, or immediately afterwards, as takes place in the lungs of animals. Thus the air, at the laft term of its alteration by dead vegetable fubftances, may be entirely deprived of its oxigen; contain a large proportion of water, the greater part of which, not being able to be held in folution, is precipitated; become charged with a portion of the vegetable matter in the ftate of vapour, which gives it a fmell more or lefs ftrong of carbonic acid; prefent even a temperature more elevated than the atmofphere, by the double condenfation which its oxigen gas experiences, both by uniting with the hidrogen, and by combining with the carbon. Thus thefe different effects, fo well appreciated by the pneu-

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matic doctrine, throw the greateſt light upon the alterations of vegetable ſubſtances by the air.

8. Every one knows that beſides the five effects, or rather beſides the ſeries of different alterations which I have juſt explained, and which characterize the chemical properties of the vegetable ſubſtances with reſpect to the action which the air exerciſes upon them, or which they exerciſe upon the air, they are at laſt decompoſed more or leſs ſlowly and completely; they undergo a kind of analyſis, which ſeparates from them by degrees all the volatile principles, and collects their fixed elements in the form of an earthy reſidue, or rather one of an earthy appearance; that in this manner, Nature employing the air at once as a reſervoir and an inſtrument, deſtroys, with the aid of time, the moſt ſolid texture of ancient trees, as well as the moſt frail and delicate fabrics of annual plants; that ſhe reſtores to the general circulation of beings the principles which ſhe had lent for ſome time to theſe organized bodies. But as this effect of ſpontaneous analyſis, of natural and ſlow decompoſition, is complicated of the actions of caloric and water with that of the air, as it gives riſe to different and very important reſults that are to be conſidered in particular; and laſtly, as it deſerves to be comprehended and treated more particularly in this ſection, in the order of facts which ſhall follow that devoted to the examination of the immediate materials of plants,

plants, I ſhall here only announce it, in order to render more methodical and more complete this outline of the alterations which vegetable ſubſtances undergo, or the chemical properties which they preſent by the action and the contact of the air. I ſhall reconſider and explain it in a more ample manner, in the fifth order of this ſection, devoted to the examination of the alterations of which the vegetable compounds are ſpontaneouſly ſuſceptible.

ARTICLE IV.

Of the chemical properties of vegetable ſubſtances treated by water.

1. THOUGH I have already conſidered water as a means of analyſis, acting upon vegetable ſubſtances, and ſerving to ſeparate from them ſome of the materials of which they are conſtituted, though I have already remarked that it may be employed as an inſtrument in five different manners, by tranquil maceration, by agitated maceration, by infuſion, by digeſtion, and by decoction, means to which we may alſo add that of diſtillation, I have not yet proceeded to examine with due attention the changes, or the chemical properties which theſe ſubſtances are capable of experiencing from the action of water, but merely the general effect of

of this agent and the influence which it may have upon the ſeparation of the principles of plants.

2. In this place another view preſents itſelf, another kind of conſideration, not leſs important and much more profound than that which related to the vegetable analyſis in general. It is neceſſary that we ſhould determine, with preciſion, all the effects which water produces upon the vegetable compounds, the different alterations which it cauſes them to experience, and afterwards the chemical properties which it exhibits in them. By approximating all the phenomena which water, employed in the different proceſſes above indicated, produces in vegetables, by comparing together all the different effects which reſult from thence in their compoſition, I find that they may be reduced to eight, which are very diſtinct, and which muſt be examined in particular, in order to appreciate their relation to the chemical properties of theſe organized bodies.

3. Theſe eight phenomena ſeem to follow each other in the order and according to the diſpoſition which I am about to lay down.

a. Abſorption and ſoftening.

b. Mechanical ſeparation of the parts.

c. The fuſion or inſulation of ſome of the immediate materials.

d. The ſolution of ſome others.

e. The

e. The new union or the mixture of ſuch of theſe immediate principles as are diſſolved at the ſame time.

f. The alteration which they undergo either by the action of the water, or by that which they naturally exert upon each other.

g. The coction, or the complicated effect of the boiling of the vegetables in water.

h. Finally, the total decompoſition, which is the termination of the action of the water, and the ultimate term of the chemical properties which the vegetable ſubſtances preſent by its influence.

It is, however, neceſſary to remark that theſe phenomena are not always produced by the action of water upon theſe vegetable ſubſtances; that caloric has more or leſs influence upon them, according to the temperature to which we elevate the water we employ; that ſince, even when we take cold but liquid water, it contains an abundant proportion of this principle, it is evident, that it always enters for ſomething into this action.

4. The firſt effect of water is known to every one, and takes place in every vegetable matter which is impregnated with this liquid, which is kept immerſed in it, or which is even placed in the air when water is precipitated from it; this matter abſorbs it, becomes penetrated with it, admits it from all ſides between its laminæ, its layers, its fibres, or its molecules; theſe are then removed from each other and ſwell; whence reſults an augmentation of volume, a change of form, an

an enlargement which are made ufe of in many of the arts, and which, as is well known, anfwer many ufeful purpofes. This effect is not merely that of fuction and of the capillary tubes, as has been afferted by natural Philofophers in their mechanical explanations; it would in that cafe have no relation with chemiftry, and would not deferve to be enumerated amongft the properties which this fcience ought to examine in vegetables. It is not confined to a mere phyfical power; it follows the laws of chemical attractions, and on this account the vegetable fubftances differ even in the manner in which they abforb water, in which they are penetrated by it, in the quantity which they abforb of it, in the degree of augmentation of volume which they experience from it, and efpecially in the adhefion which they contract with it. Accordingly, different woods fteeped in water for the fame fpace of time, augment differently in weight and volume, and dry afterwards with different phenomena.

5. When the vegetable fubftances have remained for fome time immerfed in water, thofe whofe texture is the moft delicate, are not only penetrated with the largeft quantity of this liquid, but experience alfo, by the effect of the removal of their laminæ or fibres from each other, a feparation, a kind of diffection, which detaches filaments from them, fo that thefe are precipitated or depofited at the bottom of the liquid, the tranfparency of which

which they impair by remaining for ſome time ſuſpended in it. From this action, which alſo depends upon the affinity of the vegetable molecules with thoſe of the water, there reſults a diſorganization of the former, ſoon followed by a more decided alteration, a more intimate decompoſition or change of nature, of which the firſt ſeparation has been the ſource. It is not only in the furfuraceous form or in laminæ, leaves or filaments, that the water thus detaches, by long contact, the different materials of the vegetables; frequently, this ſeparation, which takes place in conſequence of the different attraction of the immediate materials of the plants for the liquid, preſents, as it is effected, ſoft, pulpy, mucous, flaky, gelatinous ſubſtances, which float in the liquid, or which are depoſited in different layers, but this ſeparation is then accompanied with a conſiderable alteration of the ſame materials, and belongs to one of the ſubſequent effects.

6. When we employ water conſiderably heated for treating vegetables, the elevated, and eſpecially the continued temperature aſſiſting the action of the water, cauſes it to penetrate more deeply into the parenchyma and the organic texture of the plants; and this liquid, having become more active, divides, ſoftens, and entirely fuſes ſuch of the immediate materials as are ſuſceptible of this change of ſtate; ſo that without combining with the water, which even repells their union, theſe materials are nevertheleſs,

thelefs, infulated from the vegetable, and prefent themfelves alone with the properties which characterize them. Thus when we boil roots or barks for a long time in water, we fee at the furface of the liquor drops of oil, which float without mixing with the liquid. Refin, Gum-refin, and feveral other immediate materials of vegetables are affected in the fame manner, and the feparation of thefe materials contributes to the analyfis of the plants, or of the parts of plants which are fubjected to it.

7. At the fame time that thefe three effects of water take place, or after they have taken place, this liquid takes up from the vegetables fuch of the materials as are foluble in it, and accordingly as thefe are more or lefs numerous, or more or lefs abundant, the water takes up a different proportion, and favours the feparation or the analyfis of thefe materials: thefe then partake of the liquidity of the water, and cannot be feparated from it except by evaporation; and it is always with the fole and almoft exclufive intention of thus diffolving fome of the immediate materials of plants, that water is employed in their analyfis; but it is neceffary to add to what I have already faid upon this fubject, that the different foluble materials of thefe bodies are fo in different degrees, and vary according to the more or lefs foluble texture to which they belong, according to the age of the plants, and according to the particular ftate of thefe

these materials. Some of them, and we shall see that to this class belong the mucilages, the extracts, the vegetable salts, &c. are very soluble in the cold, and in small quantities of water; others require a heat more or less intense, and also a larger quantity of this liquid to dissolve them; whence it follows, that, according even to the variability of this chemical property in the plants, or the vegetable matters of whatever kind which we examine, we ought to treat them differently with respect to the proportion and the temperature of the water which we employ, as a first trial will sufficiently indicate.

8. It is not to the mere loss of these materials soluble in water that vegetables are limited, under this point of view, as to their chemical properties indicated by the action of water; there takes place also during and by the act itself of this solution, another effect equally necessary and important to be appreciated, in order to acquire a knowledge of these properties; when two, and still more so when more than two of these soluble materials pass thus from the vegetables into the water, this fluid combines and unites them in another order and under another form than than that in which they existed in the natural substance whence it has taken them: so that it must not be concluded from this experiment when employed as a means of analysis, that these matters, so dissolved and afterwards found again in the water, existed in the same state, and in

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ſome reſpect under the ſame aſſociation in the vegetables that has been analyzed. Thus the ſugar, the gum, and the eſſential ſalt which are found diſſolved at the ſame time in the water, and which adhere to each other, after having been artificially ſeparated from it, were not combined three and three in the ſame manner in the vegetables from which they proceed; and in like manner the materials that have not been touched by the water, but which have eſcaped its ſolvent action whilſt the former were diſſolved in it, are applied and united to each other in a a different manner than they were when they formed integrant parts of the texture and of the parts of plants.

9. The conſequence of this alterative and combinatory action which water exerts upon the vegetable ſubſtances which it diſſolves, as alſo upon thoſe which it leaves undiſſolved when it is brought to act upon plants, is neceſſarily a change of nature, an alteration of ſome kind, eſpecially between the diſſolved ſubſtances which muſt re-act upon each other, and become different from what they were at firſt. This is a reſult which muſt well be kept in mind in the vegetable analyſis, which, without the condition here propoſed, would lead us to commit many errors. I have ſhown in the preceding article, that the air has great influence upon the ſtate of vegetable compounds diſſolved in water, upon the product of the infuſions and the decoctions: there are

therefore here, with refpect to the chemical properties of the vegetable fubftances, three effects, which become complicated by being affociated with each other; the one is the action of the water itfelf upon the fubftance diffolved; the fecond is the combination of feveral of thefe fubftances diffolved at the fame time; and the third is the influence of the air upon this matter held in folution; whence it follows that it is not every action of water upon a vegetable that furnifhes exactly and without any alteration, the fubftances this liquid takes away from it; and this depends upon the great alterability of thefe fubftances, the flight equilibrium which keeps their firft principles combined, and the facility with which it may be broken.

10. A great part of the phenomena which I have juft enunciated in their generality, are united in the operation fo familiar to mankind, when they boil plants in water, in order to render their vegetable aliment better tafted, more tender, and more eafy of digeftion. It is well known what a great difference there is in the tafte, foftnefs, and agreeablenefs in general, between vegetables boiled in water and baked vegetables, of which I have fpoken in one of the preceding articles. It is known that the change produced by this boiling is owing to the prefence of water which penetrates them, makes them tender, foftens them, diffolves fome of their principles, changes more or lefs their nature and their properties, converts for example the

the harſh juices into mild matter, and the inſipid matter into ſaccharine ſubſtance. It is therefore very evident that this change is owing to an union of the different alterations of which I have ſpoken in the preceding numbers, and that, if we well conceive the nature of theſe alterations, it will not be difficult to comprehend perfectly the boiling of the vegetables in water; an operation the phenomena and the reſult of which chemiſts have not ſufficiently determined. They have not determined, for example, why water, holding a ſmall quantity of earthy ſalts in ſolution does not effect this boiling; which appears to depend upon the circumſtance that the water, being ſaturated with theſe ſalts, and eſpecially with the ſulphate of lime, is no longer able to diſſolve the vegetable matter, which, in this ſoftened ſtate, conſtitutes the boiling of plants. Sufficient attention has not been paid to the very uſeful power of the vapour of water in boiling pulſe, grains, and fruits, which is employed with ſo great advantage, eſpecially with reſpect to hard, raw, and ſaline water, and may ſerve in certain countries or at ſea for this important purpoſe, becauſe the action of the fire reduces only the pure water into vapour which acts upon the vegetable ſubſtances.

11. Water, like caloric and air, has the power of completely decompoſing the vegetable compound, and entirely ſeparating its principles. This is a fact which is proved by a thouſand

circumſtances, and eſpecially by that which is ſo frequently and ſo abundantly exemplified before our eyes in the immerſion of vegetables in this liquid. We ſee at every moment the plants plunged in this liquid become completely deſtroyed in it; they become ſoft, pulpy, and are reduced into a kind of ropy and putrid mucilage, which quickly diſappears. This phenomenon varies in the woods, which firſt become black in it, and afterwards brittle. It is very remarkable in the ſtalks of hemp and flax, which, by remaining too long in the water of the ſteeping-veſſels, or by too long ſteeping, are burned, become black, putrefy and entirely loſe their conſiſtence. In chemical experiments, as well as in the operations of nature, every vegetable ſolution is gradually decompoſed and deſtroyed; but theſe effects are owing to a complication of cauſes and of actions, and alſo preſent a ſeries of important differences or modifications, which it is eſſentially neceſſary to examine in the moſt detailed manner, and which I reſerve for the fifth order of facts relative to the alterations of which vegetables are ſuſceptible. Our preſent object is merely to deſcribe in general the complete decompoſition effected by water, and to explain it as the laſt term of the chemical properties and actions which the vegetable ſubſtance can preſent under the influence of this liquid.

12. It reſults from theſe eight phenomena appertaining to the re-action of water upon vegetable ſubſtances, that moſt of them conſiſt

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in a ſeries of actions, which, like thoſe of the air and of fire, tend really to inſulate the conſtituent principles of theſe ſubſtances, to change their nature, to extract them, or to reduce them to the ſtate of two or three binary compounds, or even to their primitive elements; and that this ſeries of actions cauſes the vegetable compound to paſs through ſucceſſive modifications, which frequently reſemble thoſe which it experiences in nature, and even in the veſſels of the living plants; which proves that the general progreſs of this decompoſition is uniform, and obeys conſtant and determinate laws.

Article V.

Of the Chemical Properties of Vegetable Subſtances treated by the Earths and the Alkalis.

1. IF we except ſome very well-known combinations between the alkalis and certain immediate materials of vegetables, ſuch as thoſe between the oils and thoſe baſes which conſtitute the ſoaps, ſcarcely any thing has hitherto been ſaid concerning the reciprocal action between thoſe two kinds of ſubſtances; and nevertheleſs it is not to be doubted that they have a more

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or lefs energetic tendency towards each other. The well-known energy which the cauftic fixed alkalis exert upon organic fubftances in general, is too great and too powerful for it not to be exercifed in fome manner upon the vegetable fubftances: it is therefore of importance to attempt at leaft to fupply, by fome general confideration, and by the collection of fome facts, the almoft total filence of chemifts with refpect to this fubject.

2. The dry earths, filex and alumine, produce no very fenfible alteration upon vegetable fubftances: it is well known, that when immerfed in pure and well-dried fand, they keep without alteration. Befides the advantageous ufe to which this kind of inhumation is applied, in rural and domeftic economy, in order to preferve roots and pulfe without change guarded againft the moifture, the atmofpheric variations, and the procefs of germination, when the precaution is ufed of placing them in a depth at which the temperature is not fubject to variation; we alfo know that induftrious art which preferves with a kind of frefhnefs, and even with their moft exact forms and more tender tints, plants of a delicate texture, by fprinkling and furrounding them with fine and dry fand, in veffels to the middle of which they are fixed and fufpended in their natural fituation. Thus filex has in fome fort the power of preferving the properties, the organization, and the compofition

poſition of vegetables; it prevents their alteration and ſpontaneous analyſis; it checks their ſeptic decompoſition.

3. The ſame is not the caſe with alumine: always more or leſs humid, or retaining between its molecules a certain proportion of water, argil does not ſerve in the ſame manner for the preſervation of vegetable ſubſtances; accordingly they become altered, and putrefy when ſurrounded with or buried in it. This kind of alteration, which is conſiderably rapid even with wood buried in the argillaceous earths, is entirely owing to the water which they retain; and it is only becauſe this ſpecies of earth is always moiſt and ſoft, the vegetables experience in it this decompoſition, of which, as we ſee, the alumine is the occaſional cauſe. This earthy baſe unites pretty eaſily with certain vegetable ſubſtances, with the mucilages and the oils; but this effect belongs to the hiſtory of the immediate materials of which I ſhall treat elſewhere.

4. The alkaline and acrid earths, barites, ſtrontian and lime, are very analogous to the alkalis ſtrictly ſo called with reſpect to their action upon vegetable compounds. They powerfully abſorb the water with which they are impregnated; they dry them, and even effect upon them a kind of ſemi-combuſtion, by the heat which they produce in ſeizing the water which is contained in them. There are even ſome of the immediate materials of plants upon which they exert an action of combination, as

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I ſhall ſhow hereafter. Magneſia, which is frequently preſcribed by the phyſicians, in its mixture with vegetable powders, favours the ſolution and extraction of ſome of their principles; but this action has not yet been examined or determined with ſufficient accuracy to enable me to ſay more concerning it in this place.

5 I ſhall not here ſpeak of the combination ſo well known under the name of ſoap, which takes place between the fixed alkalis and the vegetable oils, nor of the action of theſe baſes upon the colorant parts: this ſubject belongs entirely to the hiſtory of the immediate materials of vegetables, with which it is not yet time for me to occupy myſelf. I ſhall only enunciate ſome generalities relative to the manner in which we may conceive the properties which the vegetable compound preſents, when it is ſubjected to the action of the pure and powerful alkalis, whether in the ſolid or in the liquid form. Theſe baſes, which are ſo energetic and ſo greedy of moiſture, quickly take away that which is contained in the vegetables. But their action is not limited, like that of the acrid earths, to a ſimple deſiccation. When we triturate them dry with the ſubſtances, they effect a profound alteration in their texture, their organization, and their compoſition. They ſoften them, frequently reduce them into a ſoft pulp, colour them, and decompoſe them. The ſame effect takes place, but in a leſs power-

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ful degree, with the cauftic diffolved alkalis, efpecially when their folution is denfe and concentrated: then, even without the aid of heat, which however greatly augments their activity, they powerfully diffolve the vegetable fubftances, and bring them into a kind of faponaceous ftate. It is in this manner that unfized paper affumes the form of pulp, runs quickly into holes or becomes diffolved, when we employ it to filtrate alkaline leys. It is in the fame manner that linen, employed for the fame purpofe, lofes its ftrength and part of its weight; an inconvenience which is perceived even in the domeftic operations of wafhing and bleaching, when too ftrong leys are employed. There are fome vegetable fubftances, fuch as approach to the animal fubftances by the azote which they contain, which, like the latter, yield ammonia at the moment when they are triturated with folid alkalis. This phenomenon I fhall explain more at length when treating of the immediate materials of vegetables in the fubfequent orders. The cauftic alkalis, by the avidity with which they tend to unite with water, effect the decompofition of fome vegetable fubftances by infulating their oxigen and their hidrogen. This action refembles that of the acids.

6. The properties which the vegetable compounds prefent in the action which they are fufceptible of experiencing from ammonia, approach but flightly to thofe which I have juft defcribed relative to the fixed alkalis: they have

have an analogy, which may be eaſily conceived from the comparative nature of theſe ſalifiable baſes. But the weakneſs of this ſpecies of volatile alkali explains how ammonia has only in a few circumſtances even a ſlight ſolvent action upon theſe compounds. It favours, ſtill leſs than pot-aſh and ſoda, the ſolubility of ſome of theſe compounds in water, and it changes their nature but very little.

Article VI.

Of the Chemical Properties of the Vegetable Subſtances treated by the Acids.

1. THOUGH chemiſts have long employed the acids for the purpoſe of examining vegetable ſubſtances, and though they have obtained ſome advantage from them with reſpect to the knowledge of their properties, it is only ſince the great diſcovery of Bergman, of the converſion of ſugar into a peculiar acid by means of that of nitre, that this kind of vegetable analyſis has become a means of the greateſt importance for appreciating the chemical properties of theſe compounds. The pneumatic doctrine has eſpecially thrown the greateſt light upon this decompoſing action of the acids; this alone has been able accurately to appreciate its exiſtence, to determine

determine its caufes, to verify its refults, and well to diftinguifh all its phenomena. It may even be faid, that between the difcoveries of Bergman and Scheele, the two firft chemifts who have indicated the change of the vegetable compounds by the nitric acid, and the ingenious explanations founded upon other difcoveries of the French pneumatic doctrine, the diftance and the interval for the progrefs of the human underftanding, is greater than between the ancient ftate of chemiftry and the firft obfervations of the two Swedifh chemifts. No part of the fcience has made a more ftriking progrefs, nor has arrived at more beautiful refults than this: and though that of the action of the powerful acids upon vegetable fubftances has not by any means been carried fo far as it evidently may hereafter, there is neverthelefs no re-agent, which has more effectually contributed to the knowledge of the chemical properties of vegetables than thefe active inftruments.

2. It is difficult to generalize the action of the very decompofable mineral acids upon vegetable fubftances, becaufe this action differs more or lefs, according to the nature of the acid, and according to that of the organic fubftance. It may however be faid, that it always tends to deftroy thefe compounds, to caufe them to pafs through feveral intermediate ftates previous to their total decompofition, and that it efpecially converts them into feveral vegetable acids more or lefs energetic, more or lefs oxigenated,

genated, till the period when it changes them completely into water and carbonic acid; by augmenting the quantity of oxigen in general, they frequently ſeparate part of the hidrogen or of the carbon, which they burn ſeparately, and cauſe them to fly off in the form of water and carbonic acid. Thus they change the relative proportion of their firſt principles; they cauſe the nature of the vegetable compoſition to vary in many reſpects: hence the multiplied ſtates of the products, and of the phenomena to which they give riſe.

3. But notwithſtanding this multiplicity of actions and of converſions produced in the vegetable compounds, by the powerful acids with ſimple or with unknown radicals; many which depend upon the ſtrength of the acids, their quantity, and even the differences of the vegetable ſubſtances, and the temperature at which they are treated, we may however refer to three general modes the alterations to which theſe bodies give riſe, or the chemical properties which the vegetable ſubſtances preſent when treated by the acids. Sometimes in fact they are diſſolved without being ſenſibly changed; ſometimes they experience an alteration without the acid itſelf having yielded oxigen, ſometimes their nature is changed, or they are converted into new products, at the ſame time that the decompoſed acid gives them a portion of its acidifying principle. In the latter caſe, the alteration

teration of the vegetable ſubſtance is much more profound than it can be in the two firſt circumſtances. It is of importance to conſider each of theſe effects.

4. In order that the powerful acids may act only as ſimple ſolvents of the vegetable ſubſtances, it is neceſſary, either that theſe acids ſhould be very much weakened, or that the vegetable compounds of a greater or leſs degree of denſity ſhould ſtrongly reſiſt their decompoſition. The latter caſe is extremely rare, and in ſome ſort foreign to the vegetable nature: the firſt is that which moſt frequently takes place. There is ſcarcely any vegetable ſubſtance which is not ſuſceptible of being diſſolved, either in the cold or by heat, by all the acids when weakened and completely ſaturated with water; and there is alſo no acid whatever, which has not the property of effecting this ſolution, when it is made without ſenſible decompoſition on a portion of the vegetable ſubſtance; there is no change of colour in this ſubſtance, and no change whatever is diſcovered in the acid. Frequently we may ſeparate the matter thus diſſolved by means of an earth or an alkali, which ſeizes the acid, and forces it to quit the diſſolved matter. It is then depoſited almoſt without alteration, or at leaſt but very ſlightly altered.

5. But though not altered at the moment of its ſolution in a weakened acid, the vegetable ſubſtance does not remain without a more or leſs powerful alteration when this ſolution is

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kept. At the end of ſome days we find it no longer poſſeſſed of all its properties; its nature is gradually changed; it is decompoſed, and it paſſes ſlowly with the aid of time into the ſtate which it is ſuſceptible of aſſuming in the caſe where the ſame acid, when ſtronger, attacks its combination quickly and powerfully. This is obſerved conſtantly in thoſe ſolutions when kept for a longer or ſhorter ſpace of time. They are all found changed into vegetable acids.

6. The ſecond caſe of the action of the acids, which I have diſtinguiſhed with reſpect to the different properties of which the vegetable ſubſtances are ſuſceptible when treated by the acids, is that in which they are altered, changed, modified, without the acid itſelf being decompoſed, without its loſing or being ſeparated from its oxigen. The ſecond caſe had not yet been appreciated before Citizen Vauquelin and myſelf gave an account of it towards the end of the fifth year of the Republic. It takes place eſpecially in the action of the ſulphuric acid upon theſe ſubſtancs. When we ſuffer theſe two kinds of ſubſtances to act ſpontaneouſly upon each other, when for example we mix in the cold this acid with ſtraw or wood, &c. the vegetable ſubſtance is diſorganized, ſoftened, and as it were diſſolved; a remarkable quantity of carbon is ſeparated from it, and it is eaſily ſeen that it is decompoſed, as if it had been in part burned or heated in cloſe veſſels. Before the inveſtigations that have been mentioned, it was believed

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that the ſulphuric acid produced this effect by the ſeparation of its oxigen. However, as no ſulphureous acid is diſengaged during this remarkable change, and as we find the ſulphuric acid not decompoſed, not diſoxigenated, after it has taken place, it certainly proceeds from another cauſe. This is determined by examining the ſtate of the acid; it is extremely weakened without its nature being changed; it contains a large quantity of water which it did not contain before; when it is mixed with a freſh quantity of water, it does not produce, by far, the ſame heat which it produced previous to this re-action. It is therefore evident that it conſiſts in a formation of water, that the ſulphuric acid, by the great tendency which it has to unite with this liquid, has ſolicited and effected the ſeparation of a portion of the hidrogen and oxigen of the vegetable ſubſtance, and has conſequently ſet its carbon free; that this alteration, of which the acid greedy of water is the occaſional cauſe, without however relinquiſhing its own oxigen, has no limit, except the ſaturation of this acid by the water, and that it conſequently paſſes entire into the vegetable ſubſtance. We ſhall ſee that this is the cauſe of the phenomenon of etherification, or the formation of ether.

7. In proportion as this decompoſition of the vegetable ſubſtance by the concentrated ſulphuric acid takes place, as it is converted into water and carbon, a portion paſſes alſo into the ſtate of acid; it is almoſt always to the acetous acid

acid that this acidification tends: it may be obtained by diſtillation. We ſhall ſee hereafter that this acid is formed by the union of a given proportion of oxigen of carbon and of hidrogen; and it is evident that it is, like water, the product of a change of equilibrium in the vegetable ſubſtances. It muſt be remarked, that during this particular kind of alteration no effervefcence takes place; no bubble of elaſtic fluid is ſeparated, as in fact no principle of the vegetable or of the acid is diſengaged. There is only diſengaged a certain proportion of caloric by the union of the acid with the water that is formed, and in proportion to the denſity acquired by this combination, as well as to the precipitation of the carbon.

8. The muriatic acid acts in the ſame manner upon the vegetable compounds when it is concentrated, and when it is left for a long time in contact with them. The muriatic acid gas, as being very greedy of water, acts ſtill better than the liquid and fuming muriatic acid; but the action of both is infinitely longer than that of the ſulphuric acid, on account of the little activity of the muriatic acid. When we ſuffer a vegetable ſubſtance to remain for a long time in contact with this acid, it at laſt becomes colored brown, black, is ſoftened, carbonated, and the acid is found to be extremely weak. As the decompoſition of the muriatic acid has not hitherto been obſerved, ſince we knew of no circumſtance in which it relinquiſhes oxigen, it is eaſy to conceive

ceive that all the effects which it produces upon vegetable fubftances are occafioned only by the attractions of the mafs itfelf in all its integrity. Thus when, after long contact of fome of thefe fubftances, which then approach in their nature to that of the animal fubftances, with the muriatic acid, we extract muriate of ammonia from the mixture, we muft conclude that this alkali is formed, like the water, at the expenfe of the principles of the vegetable, and by the attraction which the acid exercifes upon the ammonia.

9. With refpect to the phenomena which vegetable fubftances prefent with the acids which are decompofed together with them, they all depend upon the feparation of the oxigen from thefe acids, and the transfer of this principle to thofe of the organized fubftances. Accordingly, all the acids which do not adhere ftrongly to oxigen, and which eafily fuffer it to be taken from them, produce fimilar effects. Thus the fulphureous acid, that which of all acids acts the leaft upon vegetable fubftances, has at leaft the property of difcolouring fuch of thefe fubftances as have the ftrongeft colours, by relinquifhing its oxigen to them. Thus the oxigenated muriatic acid, likewife by introducing its oxigen into the vegetable fubftances, not only alters their colours, bleaches them, and renders fome liquid vegetable fubftances concrete, but at laft burns thefe fub-

ftances,

ſtances, reduces them to charcoal, or converts them into acids.

10. Of all the acids that of nitre changes all the properties of vegetable matters moſt powerfully, when it is very concentrated, and eſpecially if it contain nitrous gas, it burns theſe ſubſtances with ſuch activity that it inflames ſeveral, and reduces them to the ſtate of charcoal. When a little weaker, it changes the colours, deſtroys them, or communicates to them a yellow tinge, which is unalterable or indelible. This effect of the nitric acid has long been known, but not explained: but it is evident that it is owing to the quick ſeparation of the oxigen and the large quantity of this principle, which ſuddenly ſeizes the hidrogen of theſe ſubſtances, and proceeds ſo far as to inflame them: but it is not in this violent action that the moſt uſeful influence of this acid upon vegetable compounds conſiſts. When ſtudied according to the lights of the pneumatic doctrine, this influence ſerves at preſent to acquaint us with all the properties of theſe compounds: it is in the appreciation of theſe effects that the French chemiſtry has rendered the moſt ſtriking ſervices to Natural Philoſophy, as I ſhall ſhortly ſhow.

11. Though the action of this acid varies more or leſs according to the diverſity of the compoſition of vegetable ſubſtances, and it is by examining each of the immediate materials of plants in particular, that we can appreciate all the

the different circumſtances of this action, we may neverthelefs deduce even from all the variations of the effects which it produces, a common mode, a generalized reſult, which embraces the collective whole of theſe variations, and which, while it ſerves to render them intelligible when it ſhall be neceſſary to treat of each of them, may at the ſame time ſerve to determine in what the totality of the effects which it produces upon theſe vegetable compounds conſiſts, and lead us to characterize their chemical properties: it is in this manner, and without entering into the details which belong to the following order of facts, that it is eſſential in this place to conſider the action of the nitric acid.

12. As the total tendency and the term of this action is the complete decompoſition of the vegetable compounds, their reduction into water and carbonic acid, and as it proceeds more or leſs rapidly towards this term, when we employ ſtrong and concentrated nitric acid; in order to underſtand and clearly to aſcertain all the intermediate degrees of this decompoſiion which it is capable of effecting, we take it weakened with a certain quantity of water; for example, at 28 or 30 degrees of the ordinary areometer, and frequently it is even diluted with from half its weight to twice or thrice its quantity of water. It is left to act in the cold, or its action is favoured and made to commence by the aid of a gentle temperature, or it is rendered more violent and energetic by heating it more

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ſtrongly or for a greater length of time. In the firſt caſe, we have only a rare and ſlight effervefcence, the product of which is nitrous gas, mixed with a ſmall quantity of carbonic acid. In the ſecond, the proportion of this diſengagement is more conſiderable; and in the third, we may go ſo far as completely to decompoſe a portion of the acid: for as we employ from three to ſix times the weight of the vegetable matter which we wiſh to treat, there is always more than is required, in order to obtain the products which we ſeek, and the reſults which we expect.

13. In each of the circumſtances which have juſt been enunciated, the products of the action of the acid differ; the ſtronger this is, the more in general we obtain of nitrous gas and carbonic acid gas; conſequently, the more oxigen there is ſeparated from the nitric acid, the more carbon there is taken from the vegetable ſubſtance, and burned by the oxigen. The general, or the moſt conſtant and moſt abundant product of this reciprocal and ſimultaneous decompoſition, is a ſeries of different vegetable acids; ſometimes to the number of three or four, ſometimes a ſingle one, or at leaſt only two, all compoſed of hidrogen, carbon, and oxigen, whoſe characters of compoſition conſiſt in the different proportions of their three principles, and of which I ſhall give an account amongſt the immediate materials of vegetables; for I muſt here obſerve, that that which is the

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moſt important and the moſt deciſive for the pneumatic doctrine, adapted to the vegetable analyſis, what moſt proves its ſtrength and ſtability, is that the acids artificially compoſed by the nitric acid acting upon the gums, ſugar, the leaves, the extracts, the woods, &c. are perfectly ſimilar both in their properties and in their intimate nature, to thoſe which are ſpontaneouſly formed by the progreſs of vegetation; which proves that the chemical art acts like the living powers which direct the growth and the function of plants.

14. The various acids which vegetable ſubſtances yield when treated by the nitric acid, proceed not only from the diverſity of theſe ſubſtances, but alſo from the manner in which they are treated by this acid: ſo that, after an attentive obſervation of what happens in theſe different treatments, we may obtain at will, as far as a certain point, ſuch or ſuch a ſpecies of vegetable acid, or determinate proportions of two of three of theſe acids: for this purpoſe it is ſufficient to ſtop at different periods, or to urge more or leſs the action of the nitric acid. We may alſo aſſure ourſelves of the point at which we have arrived in the vegetable decompoſition by the quantity and the nature of the nitrous gas, and the carbonic acid obtained; the more the gaſes are abundant, the more we are advanced in this decompoſition. By a ſeries of theſe beautiful reſults we may ſee, that as the conſequences of the alterations is the perpetually

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increafing feparation of a proportion of carbon, we can never make the vegetable decompofition proceed otherwife than in a given progreffion: we can never make a ftep backwards. An acid firft formed, when it paffes into another acid, does not appear any more in the firft ftate; and we fhall fee that this progreffive acidification, the moft common and moft ftriking product of the energy of the nitric acid, when it has once arrived at the oxalic or acetous acids, the leaft carbonated and the moft oxigenated, if we wifh to carry the nitric decompofition ftill further, the vegetable nature vanifhes as it were under the efforts of the chemifts, and the whole is reduced in his hands into water and carbonic acid. At this term, this action of the nitric acid becomes confounded with the effect of combuftion.

15. It alfo follows from the exact, though general notions which I have juft given, that by obferving with much attention, and by determining with great exactnefs the quantities of nitrous gas, and of carbonic acid gas, formed and difengaged during the different degrees of the action of the nitric acid, thofe of the different acids obtained at different periods of this action, and finally thofe of the water and of the carbonic acid obtained at the laft term of this total difgregation of the vegetable principles, we may analyze with the greateft precifion both the different vegetable fubftances, which

which we may have taken for the ſubject of our operation, and the particular and ſucceſſive acids which we may have obtained in the ſeries of the different periods of this work. Thus in the courſe of a ſet of experiments which Citizen Vauquelin and myſelf jointly made upon the vegetable ſubſtances, we employed with great ſucceſs the nitric acid, in order to determine the proportions of the primitive principles, hidrogen, carbon, and oxigen, of a conſiderable number of ſubſtances, the relations of whoſe nature and compoſition it was neceſſary for us to aſcertain and compare.

16. Laſtly, there are ſome vegetable ſubſtances upon which the action of the nitric acid is not confined to producing the effects of acidification: by converting them into acids, it ſometimes changes a portion into a kind of fat oil: in others it at the ſame time produces a ſort of reſin; with the former it affords powders inſoluble in water, and ſoluble in the alkalis, without however being fuſible after the manner of the fats; with the latter it diſengages and compoſes pruſſic acid, and almoſt always produces at the ſame time ammonia. Moſt of the laſt-mentioned converſions or modifications, which are effected but ſeldom, and which take place only with the gluten, the wood, the ſuberous barks, the funguſes, &c. when treated with the nitric acid, indicate in theſe ſubſtances a compoſition very analogous to that of the animal

animal ſubſtances, to which in fact they approach by other characters and other chemical properties. We ſhall treat of theſe more in detail in the next order of facts.

Article VII.

Of the Chemical Properties of Vegetable Subſtances treated by the Salts.

1. AUTHORS have hitherto omitted, or nearly omitted to treat, amongſt the chemical properties which diſtinguiſh vegetable ſubſtances, of the mode of their alteration by the ſaline compounds; becauſe too little attention has been paid to this mode itſelf, and it has been thought too ſlight or too indiſtinct to be capable of ſerving as a character. It is true that chemiſts have either not yet obſerved the action of the ſalts with ſufficient attention, or not found them ſufficiently powerful, in order to apply it to vegetable analyſis; and nevertheleſs, all the facts which the practice of the arts preſents relative to the uſe of the different ſalts in the preſervation or in the preparation of a great number of vegetable ſubſtances, exhibit a ſucceſſion of phenomena which are ſufficiently characteriſtic of theſe ſubſtances in order that we ſhould not neglect the examination of them, nor reject their application to this part

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of chemiftry as ufelefs. It is this economical object which I propofe here to trace, with a view to determine the properties which vegetable fubftances exhibit when treated according to different proceffes by various faline fubftances: to this I fhall fubjoin fome refults of chemical experiments that have hitherto been too much neglected.

2. Though the fulphates are rarely altered by moft of the vegetable fubftances in their habitual ftate, though they experience no alteration from thefe fubftances in their fimple contact, the cafe is not the fame when we let them remain for a long time in this contact, or when we raife their temperature very much at the moment when it takes place. Though the faturated folutions of alkaline or earthy fulphates in general defend moft vegetable fubftances from fpontaneous alteration, this prefervation is not prolonged beyond a certain term; after which the fubftances, being decompofed in the midft of the liquid, effect, with the aid of their hidrogen and their carbon, the decompofition of the fulphates, and gradually infulate the fulphur. It is in this manner that water charged with fulphate of lime lets fall fulphur, and exhales the fetid fmell of an hidro-fulphuret when it is left for a long time in contact with vegetable fubftances: it is in this manner that the filth of towns, accumulated and buried with fragments of plafter of Paris, and moiftened for a longer or fhorter fpace of time, have

have filled the fragments of these materials with crystallized sulphur, which has gradually separated from the sulphate. The same action takes place by time, as is rapidly effected when we violently heat sulphates with the same vegetable substances, which convert them into sulphurets by the action of their hidrogen and of their carbon. It is known, that natural waters which contain sulphate of lime in solution do not possess the property of boiling esculent vegetables well, and I have already shown that this depends upon their saturation with this salt; lastly, it is easy to conceive that the same waters, when circumstances favour the separation, the deposition and the crystallization of the earthy salt which they contain, and when they bathe on all sides the parts of vegetables, such as leaves, stalks, barks, must form upon these substances a covering or deposition, a real incrustation of sulphate of lime, which preserves them under this unalterable and little soluble covering. It is in this manner that in the graduating sheds of salt works, the fragments of the brush-wood become encrusted with lamellated and crystalline sulphate of lime which the evaporation of the water by the agitated and compressed air separates from it incessantly.

3. Water charged with the triple and acid sulphate of alumine, alum, is also used in order to preserve various vegetable substances; but it gradually effects their decomposition, and

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mucous flakes or filaments are ſeparated from it, which announce its alteration. The utility of this ſalt in the art of dyeing is known, the advantage which is derived from it for brightening, and eſpecially for fixing and giving ſolidity to many vegetable colouring matters. In the hiſtory of theſe colours, I ſhall ſhow that the property by which this ſalt fixes them, depends upon the ſtrong attraction which the alumine exerts upon theſe matters.

4. The nitrates exert only a feeble action upon moſt of the vegetable ſubſtances, of which they render the texture more denſe, and defend it againſt its own mutability, and of which they frequently alſo heighten the tints in their coloured parts: but chemiſts ſometimes employ the nitrate of pot-aſh with another view in the examination of theſe ſubſtances; it ſerves, by expoſing the mixture with theſe ſubſtances to a high temperature to burn them, to deſtroy their hidrogen and carbon more or leſs completely, to extract from them the fixed ſaline and earthy ſubſtances, and to prove in them the exiſtence of ſome metallic oxides, more eſpecially thoſe of mangaueſe and iron. If we perform this experiment with care and in cloſe veſſels, ſo as exactly to collect the elaſtic fluids which are formed and diſengaged, we may thus determine the proportion of the hidrogen, carbon and oxigen contained in the vegetable ſubſtance which is examined, and at the ſame time that of the fixed ſubſtances which remain.

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Sometimes the nitrate of pot-aſh, heated ſtrongly with the vegetable ſubſtances, yields as the reſidue a real pruſſiate, is even employed and compared in this action with that of the fixed alkalis, in order to aſcertain in theſe bodies the property of affording pruſſic acid, or the colouring matter of Pruſſian blue compared with that which different animal ſubſtances preſent.

5. It is known how great uſe is made in domeſtic economy and in the arts, of the muriate of ſoda in order to preſerve a great number of products of vegetables or vegetable parts. Thus it is cuſtomary to ſoak in brine, or the ſaturated ſolution of this ſalt, pulſe, ſome products eſpecially of the leguminous kind, grains or pods, roots, leaves, and even delicate flowers; the leaves of roſes arranged and covered with layers of this ſalt, are frequently preſerved in this manner in the ſhops of the perfumers, in order afterwards to diſtil them at a ſeaſon more or leſs diſtant from that in which they have been gathered. Some chemiſts have imagined that the muriate of ſoda, kept for a long time in contact with liquid vegetable ſubſtances was decompoſed, and that the ſoda was inſulated; but no experiment has yet proved the truth of this aſſertion. This ſalt is frequently employed in the decoctions and diſtillations of vegetables in order to permit the water to aſſume a more elevated temperature, and thus to favour the diſengagement as well as the volatilization of

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ſome products, the quantity of which is augmented by this proceſs.

6. It has not yet been propoſed to uſe the ſuper-oxigenated muriate of pot-aſh in the vegetable analyſis ; it is, however, one of thoſe compounds which might prove of the greateſt utility. Citizen Vauquelin and myſelf, in our inveſtigations relative to detonations by percuſſion, have found that the vegetable ſubſtances, and eſpecially gum, ſugar, farina, like the oils, alcohol, ether, have the property of burning with great energy and fulminating by percuſſion, after having been mixed with ſuper-oxigenated muriate of pot-aſh. It is evident, that by performing this operation in proper apparatuſes, it would be poſſible to collect the water and the carbonic acid formed by the union of the hidrogen and of the carbon of theſe ſubſtances, either with their own oxigen, or by that which ſhould be furniſhed by the ſuper-oxigenated muriate of pot-aſh ; and that as this ſalt brings only pure oxigen into this powerfully decompoſing action, and leaves as reſiduum only muriate of pot-aſh, it would be eaſy to determine, with the aid of its action and of its products, the exact proportions of the principles which originally compoſe vegetables, comprehending in them even that of the fixed ſubſtances which would remain with the reſidual muriate of pot-aſh, which it would be eaſy to ſeparate.

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7. The phosphates can be of no other use, in the investigation of the chemical properties and of the analysis of vegetables, than that of ascertaining the presence of some earths or of some metallic oxides in their fixed residues, in their coals or in their ashes; and that the fusing and vitrifying action which they exert does not differ from that which is exercised by the saline or metallic substances which have already been examined. The fluates and the borates are not capable of throwing any more light upon the subject; accordingly, nothing has been said concerning the action of all the salts upon the vegetable substances, and it has been absolutely impossible to draw any induction from them towards the knowledge of the chemical properties which characterize these organized substances.

8. The carbonates exert a little more action than the three last mentioned kinds of salts upon the vegetable compounds; carbonate of soda is frequently employed in pharmaceutical processes in order to extract more quickly, more abundantly, or more completely, some of the immediate materials of vegetables, by means of infusion or decoction in water. Thus it has long been known that when water is sharpened with a little *fixed salt of tartar*, or *unsaturated carbonate of pot-ash*, more resin is extracted from the dry woods, roots or barks; but we shall see in the subsequent order of facts that this more abundant extraction is accompanied

nied by a peculiar combination between the alkali and the root. It is generally known that the folution of carbonate of lime in a natural water, which it renders raw or hard, is an impediment to the boiling of vegetables, on account of the faturation of this water, which prevents its re-action upon the vegetable fubftance. It is alfo known that plants or their parts, immerfed with water highly charged with this earthy falt, by means of an excefs of carbonic acid, become covered with depofited and concreted molecules of this falt, in proportion as it quits the water, the folvent acid of which efcapes into the air. By this fimple procefs are formed the calcareous incruftations, the ofteocollæ, &c. when the vegetable fubftance is gradually deftroyed, and when it leaves a fort of hollow mould, which reprefents all its parts with great exactnefs. The carbonate of lime, depofited in minute particles in this hollow fubftance, affumes the form of the vegetable; and hence arife the pretended petrifications, which were formerly defcribed with a kind of complacency, and upon which, for a long time, many differtations were written and many abfurd fyftems propofed; and of which the production is fo fimple and fo eafy to be explained fince the difcoveries of the pneumatic doctrine.

Article VIII.

Of the Chemical Properties of Vegetable Substances treated by the Metals, the Oxides and the Metallic Solutions.

1. THE metallic fubftances, their oxides and their folutions do not prefent, any more than the falts, to the hiftory of chemiftry, real inftruments that have yet been employed in the examination of the chemical properties of vegetables, though when we are well acquainted with their nature and their energy, it is eafy to forefee that they may be employed for this purpofe with great advantage. If we except fome particular means of analyfis that have been put in practice only by Bergman and Scheele, and fince their time by fome chemifts who have followed their footfteps, for examining the new acids which they have difcovered, the action of thefe powerful re-agents, has not been confidered under any general point of view, in order to inveftigate and appreciate, in their collective whole, the chemical properties of the vegetable fubftances. I fhall here endeavour to give an idea of the advantage which may be derived from it, by inferferring from the fmall number of facts that are known concerning this action, what it may be expected hereafter to furnifh to this new branch of chemiftry.

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2. The metallic fubftances collectively prefent only three modes of influence, which they experience from the chemical properties of vegetable fubftances. Either they are completely unalterable by thefe fubftances, though fome weak alchemifts have attributed to feveral vegetables the myfterious power of changing the properties of the metals, and even of effecting their tranfmutation. Or, they are more or lefs oxidable by thofe which, bearing the character of acid, are capable of acting as fuch by a more or lefs powerful attraction for the metallic oxides, and by the property of effecting their formation by the decompofition of the water. Thus iron and copper are fuddenly coloured and gradually oxidated, corroded and diffolved by the four, afcerb, and more or lefs ftrong tafted vegetable fubftances as by the pure vegetable acids themfelves. Finally, the metals are coloured, fpotted, covered and even changed into metallic fulphurates by their longer or fhorter contact with vegetable fubftances containing fulphur, fuch as the cruciferous plants, &c. It is evident that the two latter modifications of the chemical properties of vegetables with refpect to mineral fubftances cannot afford any very great light, but only a few ideas, or general data relative to the vegetable compofition.

3. The metallic oxides are more ufeful, and prefent a much ftronger action than the metals

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when we conſider them under the ſame relation. The quantity of oxigen which is united with them here performs functions more or leſs ſimilar to thoſe of the acids which have been examined in one of the preceding articles. Thoſe acids in particular which adhere the leaſt to this combuſtible principle, and ſuffer it the moſt eaſily to be ſeparated from their compoſition, are the moſt capable of altering the vegetable ſubſtances upon which they are made to act. It is thus that in general they tend to diſorganize, to deſtroy, to burn the vegetable compounds; and ſuch is the laſt term of their action upon thoſe compounds. But they do not always carry their energy to this extreme point; frequently they yield only a portion of their principle, which penetrates the vegetable ſubſtances, thickens and condenſes, or ſimply oxidates, without decompoſing and completely deſtroying them. Such is the habitude of the vegetable oils when heated with the metallic oxides, and which, in the preparation of plaſters, aſſume conſiſtence at the ſame time that they acquire a kind of ſaponaceous nature. It is by the ſame property that ſo many vegetable liquors become more or leſs denſe, flaky and tenacious, when metallic oxides are added to them, and particularly when they are heated with theſe ſubſtances.

4. A particular action takes place between the metallic oxides and the colouring parts of vegetables: though it may be referred in general

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to what has already been explained, it muſt however be remarked, that it is ſtill ſtronger on account of the attraction which ſubſiſts between theſe two kinds of bodies. The oxigen ſeems in fact to be the cauſe of the connection which unites theſe two ſubſtances ſo cloſely with each other, for the metals of theſe oxides do not preſent the ſame property of combining with the colouring matters; but the combination thus formed does not admit of the ſeparation of this principle; it remains united at the ſame time both to the oxide and to the colouring matter, the colour of which it exalts, fixes, and renders more permanent.

5. The ſolutions of the metals in acids produce a great variety of effects with vegetable matters, and their action differs according to the nature of theſe compounds. We ſhall ſee, in the hiſtory of the vegetable acids, how many different characters they preſent with the moſt of theſe ſolutions, and what effects ſimple and complicated attractions take place when theſe different ſubſtances are mixed with each other. It is neceſſary, in order to comprehend the reciprocal actions of the metallic ſolutions, and of the vegetable compounds, firſt to ſeparate in the mind thoſe effects which can be produced by the ſaline bodies analogous to thoſe deſcribed in the fifth ſection of this work, which are frequently found to conſtitute part of theſe compounds; otherwiſe we might attribute to the vegetable matter what belongs

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only to ſubſtances foreign to its nature, which may in this manner be mixed with it. Thus the precipitations produced by the ſulphates and the muriates, which the vegetable liquids ſo often preſent when we mix them with the nitric ſolutions of moſt of the white metals, muſt firſt be ſeparated from the chemical effects which the vegetable ſubſtance is capable of producing. Thoſe effects are known by the form, the colour, and eſpecially by the examination of the precipitates.

6. When we admit this firſt and eſſential diſtinction, and in ſome meaſure ſubtract from the chemical phenomena produced by the vegetable ſubſtances mixed with the metallic ſolutions, thoſe which belong to the ſalts already known, we find that the ſubſtances of this order are either preſerved, or condenſed, or coloured, or burned, or decompoſed and precipitated by the metallic ſalts. Nothing is ſo frequent as the more or leſs intenſe coloration of white vegetable ſubſtances by the contact of metallic ſolutions; and beſides the ſpots of all kinds with which the linen cloths employed in chemical laboratories become covered by the contact of theſe ſolutions, this kind of alteration is proved by the grand and beautiful reſults of the art of dyeing. The precipitation occaſioned by the ſame compounds, added to the vegetable liquids, takes place eſpecially with the ſaps, expreſſed juices, infuſions, and decoctions. As the metallic ſalts are themſelves

decompoſed

decompofed by thefe mixtures, Citizen Berthollet has propofed to employ the decoction of Peruvian bark, in order to deftroy, even in the ftomachs of perfons who have taken them inconfiderately or by miftake, the effects of the folutions of tartrite of antimony and pot-afh, and of the fuper-oxigenated muriate of mercury.

Fourth Order of Facts relative to the Vegetable Compounds.

Of the different Vegetable Matters in particular, or of the immediate Materials of Vegetables.

ARTICLE I.

Concerning what is to be underftood by the expreffion or term of immediate Materials of Vegetables, and of their feat in the vegetable organization.

1. I HAVE hitherto fpoken only of vegetable compounds in the aggregate, and have confidered them only as if they formed one and the fame fubftance, the nature and the general properties of which I have explained; but no one is ignorant that the matters extracted from vegetables are really very different from each other in their form, their confiftence, their tafte, their fmell; no one confounds fugar with

with gum, or theſe two ſubſtances with oil, or oil with wood ſtrictly ſo called. The uſes to which each of theſe principal vegetable matters is applied for the purpoſes of life, teach every one to diſtinguiſh them from each other, and ſhow that it is not only in the different ſtructure of their parts, for example of their roots compared with their ſtalks, their leaves, their flowers, &c. that vegetables differ from each other, but even in the particular and different bodies, which each of their parts contain ſeveral at the ſame time. Thus the ſweet almonds preſent upon their ſkin a reddiſh powder which is removed from them by friction, in their interior part an oil which is extracted by preſſure, and a pulverulent maſs, friable and white like ſtarch, which remains after the expreſſion of the oil.

2. This is the ſimple notion of what I term immediate materials of vegetables; they are all ſubſtances varying in their properties, in their taſte, their ſmell, their ſolid or liquid ſtate, their conſiſtence, their nutritive, medicinal, or poiſonous properties; which may be ſeparated from the different parts of plants, and eſpecially from the ſame part, and which by their arrangement and diſpoſition in this part do immediately conſtitute it. Their general or diſtinctive character is their ſeparate exiſtence in the different parts of the plants, and eſpecially the poſſibility of their being ſeparated or extracted without experiencing alteration or change: ſo that they

they are obtained abſolutely ſuch as they were in the vegetable compounds, and without their having been cauſed to undergo any alteration capable of rendering their nature different from what it was in the organs of the plants of which they really formed integrant parts.

3. It is on this account that, when conſidered with reſpect to the vegetables to which they belong, and which are more compounded than they, becauſe theſe materials only conſtitute their different parts, they were firſt termed the immediate principles of plants, either becauſe they were found to poſſeſs the property and the character of really forming the vegetables by their union, or becauſe they were ſeparated from them by an immediate analyſis, or by immediate means. This is the reaſon why I have elſewhere deſignated, by the name of *immediate analyſis*, that in which we obtain by a firſt operation, and without complicated apparatus or proceſſes, the matters contained in a compound; and I have choſen the principal and moſt ſtriking example of this manner of analyzing vegetables. It is ſufficiently evident that theſe materials could not be termed *principles*, except ſo far as they were compared with the entire plants of which they are compoſed; but this is an expreſſion which ought not to be retained, becauſe they are not really principles: accordingly chemiſts formerly employed them to furniſh an example of what they called prin-

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ciples principiated, or formed themfelves of other principles much more fimple than they. I have therefore thought I ought to relinquifh this ancient expreffion of *principles* of vegetables, and fubftitute inftead of it, that of *immediate materials*, which very well expreffes the notion which ought to be formed of them relatively to the vegetable compofition.

4. It is fcarcely neceffary here to repeat, that all the immediate materials are the products of the work of vegetation; it is only of importance to obferve, that a vegetable fubftance, or a vegetable part, never confifts of a fingle matter only, but of feveral at a time, which may be feparated and obtained, disjoined from each other. It follows that each of the immediate materials of vegetables muft be placed in a particular kind of organs, and that its fpecial and in fome meafure individual compofition, is owing to the particular ftructure of each organ. However, it is not to be fuppofed that there are as many orders of veffels or of cells, as there are of immediate materials of vegetables: for the number of thefe amounts at leaft to twenty, as I fhall foon fhow; whilft the number of orders of veffels does not exceed five that are different from each other, as I have fhown in a preceding article. It follows therefore, that each clafs of textures, or of the organs of vegetables, contains a certain number of immediate materials different from each other. What I am about to fay concerning

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the method of obtaining theſe materials will confirm this aſſertion, as we may actually extract from a ſingle texture ſometimes three or four of theſe different materials.

ARTICLE II.

Of the Manner of extracting the immediate Materials of Vegetables.

1. THE character of the immediate materials of vegetables being to preſent all the properties which they had in the plants themſelves, of which they formed part, it is evident, that in order to obtain them ſuch, we muſt employ means which cannot in any manner alter them. If each of theſe materials were particularly placed in a very diſtinct ſituation, it would be ſufficient to know this ſituation for each of them, and to extract the ſubſtance which we wiſhed to obtain by detaching this part; and in this caſe the proceſs would be entirely mechanical. This method is practicable only for ſuch of the materials as are contained, in the liquid form, in particular cells, or with ſuch as in the ſolid or pulverulent form are ſeparated and covered with a cruſt or membranous covering, or laſtly, with ſome which, being inſulated and produced by a particular excretion, are found pure on the outſide of the

the vegetables, or of ſome of their organs, whether upon the bark, or upon the leaves, or between the open parts of the flowers, or upon the ſurface of the fruits.

2. It reſults from this diſtinction, that there are firſt of all three mechanical methods, all equally ſimple and equally certain, of extracting or obtaining ſome of the immediate materials of vegetables. When theſe materials, frequently ſuſceptible of becoming thick in the air, iſſue ſpontaneouſly in the liquid form from certain points of the ſurface of plants, whether through the extremities of dilated veſſels, or through the fiſſures and crevices which are formed in conſequence of a kind of plethora or turgeſcence, which has violently diſtended the ſides of theſe veſſels, we ſimply gather them by hand. It is in this manner that the gums, the reſins, and the balſams, are collected: nature herſelf preparing theſe juices in a peculiar claſs of veſſels, cauſes them to iſſue out by a real ſecretion and excretion ſimilar to what takes place in animals. I have indicated this general proceſs elſewhere, under the name of the natural mechanical analyſis. We ſee that it affords immediate materials.

3. Some immediate materials of vegetables, though very abundant in the interior of theſe organized and living bodies, iſſue from them with difficulty and in ſmall quantity, or even in ſome circumſtances not at all. Human induſtry has diſcovered how to remedy this inconvenience,

venience, and to adopt a fimple method of augmenting their tardy emiſſion at pleaſure, or determining it when it does not take place ſpontaneouſly. Thus the reſinous trees are bored with tools, in order to obtain the juices which then flow abundantly; the heads of poppies are cut to extract from them the white juice, which, as it dries upon the exterior ſides of theſe capſules, forms opium; and the leaves of the aloe, the ſtalks of the euphorbium, the roots of the ſcammony, the trunks of many trees, in order to obtain the extractive or gum-reſinous juices which are contained in them more or leſs abundantly. It is alſo by this proceſs that the manna is extracted from the aſh, &c. the ſap from the birch, the yoke-elm, the beech, the vine, the ſaccharine juice from the ſugar-maple, the elaſtic gum from the hevoea-caoutchouc.

4. In other caſes, when the proper juices which repreſent ſome immediate materials of vegetables, are incloſed in numerous veſicles arranged in ſome parts that are inſulated, or may eaſily be inſulated, theſe veſicles are opened by means of raſps, or the more or leſs ſoft and delicate texture which covers them is taken off, and they are expreſſed either with the hand or with the aid of a preſs: in this manner the juice is ſeparated from the ſolid and diſorganized parenchyma belonging to the veſicles in which it was incloſed. Thus the volatile oil is

is extracted from the cellular ſkins of the lemon, orange, and bergamot.

5. This kind of diſſection, though groſs and diſorganizing, is not always ſufficient for obtaining ſeveral of theſe liquid materials. When they are deeply hidden in veſſels which occupy the whole thickneſs, the whole continuity, and eſpecially the deep part of a freſh vegetable, or in cellules formed in the very centre of the fruits; when theſe juices cannot be extracted except after the whole texture has been entirely bruiſed or completely deſtroyed; when they are intimately mixed with pulpy or paſty ſubſtances which are impregnated with them: we are then obliged to bruiſe, to grind, or to pulverize theſe vegetables or parts of vegetables, and to ſubject the pulp or the paſte which is thus formed to the more or leſs violent force of a preſs. In this manner the oily and feculent ſeeds are treated, in order to extract the oil from them, and the tender and ſucculent plants, in order to ſeparate their juices. Bruiſing or violent preſſure generally cauſes ſeveral of the liquid immediate materials to run out at the ſame time, with part of the fibrous, mucous, feculent, or ligneous parenchyma, which formed the ſolid portion; but repoſe and decantation are generally ſufficient for purifying theſe materials, and ſeparating them with ſufficient exactneſs, without any other means.

6. Filtration through linen or paper is one of

of the moſt ſimple and moſt certain means of ſeparating ſeveral of the immediate materials of vegetables when confounded together in a liquid: the light fecula, which renders the juices turbid, the mucous juices mixed with reſinous or oily bodies that do not paſs through fine paper already moiſtened, are very eaſily ſeparated from each other by this mechanical proceſs. Mere repoſe is frequently ſufficient for obtaining this ſeparation. Thus, for example, the acid expreſſed juice of lemons, of oranges, of currants, of cherries, &c. when kept for ſome time, depoſits a more or leſs conſiderable quantity of inſipid gelatinous mucilage, which was at firſt diſſolved in the acid: but almoſt always this ſeparation, this kind of parting by the operation of time, is effected only by virtue of an intimate alteration, of a more or leſs advanced change in the very nature of the vegetable liquids, which, as I have already ſhown, are extremely ſubject to decompoſition. We ought not therefore to have recourſe to this means for obtaining the different immediate materials contained in theſe liquids, except in the caſes where they ſeparate very ſpeedily, and before we have cauſe to ſuſpect any alteration in the combination of theſe materials; an alteration which ſometimes takes place very ſpeedily.

7. When the immediate materials which we wiſh to ſeparate are in the ſolid form, and ſuſceptible of aſſuming that of powder by trituration or pounding, after they have been reduced

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into a pulp or paſte, either with the water of verdure of the vegetable parts which contain them, or of foreign water which may be added to them while pounding or bruiſing them by different means,—they are then diluted with a large quantity of freſh water, which by ſeparating all the pulverizable molecules, from each other keeps them firſt for ſome time ſuſpended, and afterwards depoſits or precipitates them more or leſs pure, inſulated and ſeparated, or deprived of the portion of ſoluble matter foreign to the pulverulent materials that remain in the water. This kind of waſhing is particularly employed in order to obtain the amilaceous and the fibrous fecula.

8. All the means that we have hitherto enunciated are entirely mechanical; there are ſome others which, without being equally ſimple but appertaining to ſome chemical operations, do not however require inſtruments or actions ſufficiently powerful to alter, or at leaſt ſenſibly to change the nature and the compoſition of the immediate materials of vegetables. Such is, in ſeveral circumſtances of this extraction of the immediate materials of plants, is the action of fire. Frequently theſe materials, being deeply hidden or intimately contained in the interior of the vegetable cells, where they are at the ſame time ſolidified and attached to their ſurface, cannot be extracted from them by mechanical means; ſimple diſſection, pounding, waſhing, are then no longer capable of detaching them

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from the places to which they adhere, and ſeparating them in order to obtain them alone. Frequently alſo, though they do not poſſeſs the ſolid form which I have juſt mentioned, but are in the liquid form, their imperceptible drops are contained in ſuch ſmall cells, and at the ſame time ſurrounded with ſuch dry teguments, that it would be in vain to attempt to extract them by all the proceſſes of trituration and of preſſure that have been indicated. In this caſe by macerating the vegetable parts which contain them for ſome hours in cold water, the ſides of the cells in which they are contained become ſoftened and diſtended; the ſmall drops or the lamellated flakes of the immediate materials of which I ſpeak begin to be inſulated, and detached; and by afterwards applying a gentle heat to the vegetable parts thus macerated, the caloric which penetrates the molecules of the immediate materials we wiſh to obtain fuſes them when they are ſolid, detaches them more when they are liquid, and at laſt volatilizes them, gives them the form of vapour, and enables them to be extracted by diſtillation. This is what happens in the diſtillation performed in order to obtain the volatile or eſſential oils. It is evident that this chemical proceſs is founded upon the property which theſe immediate materials poſſeſs, of being fuſed and reduced into vapour without undergoing any kind of alteration in their nature and compoſition. There are, however, very few of theſe materials that are fusceptible of being difengaged in this manner without alteration, by the mere fufing and volatilizing action of the fire.

9. But fince many other of thefe materials, placed in the fame condition as the preceding, that is to fay, inclofed in fmall cellules, or thick and folid, fo as not to be capable of being extracted by any means of tapping, are at the fame time foluble without being altered by water, alcohol, the oils, and fometimes even by the acids very much diluted: for want of other practicable proceffes for their extraction, one or the other of thefe folvents is ufed in order to obtain them feparate. Sometimes indeed two, or even more, of thefe immediate products of vegetation are diffolved at the fame time in the fame liquid employed for extracting them: different means are then ufed in order to obtain them feparate; flow evaporation, the admixture of different liquids, and fometimes even certain appropriate re-agents anfwer this purpofe. Here alfo, as in all the foregoing proceffes, we imitate the method of nature, which, by the aqueous folution of the fap or of the proper juices, carries the immediate materials of plants towards the furface of thefe organized bodies, and frequently caufes their feparation by evaporation to enfue by the atmofpherical air and heat.

10. In a word, all the operations, whether mechanical or chemical, but not alterant, which

are practifed in order to procure the different immediate materials of vegetables, and the different products to which vegetation has given rife, however varied they may be, even in the concife account which I have given of them, and ftill more fo in the genius and the refources of the chemift who wifhes to obtain them, coincide in this fingle point, that they feparate without caufing them to undergo any change which can alter their nature, the different matters which are contained in an entire vegetable; that they enable us to diftinguifh thefe matters, and afterwards to examine each in particular, in order to determine their characters, properties, relative differences and compofition; fo that the mutual extraction and feparation of all thefe immediate materials is the firft fpecies of analyfis that is applied to vegetables.

Article III.

Of the Enumeration and Claffification of the immediate Materials of Vegetables.

1. WHEN we have fucceeded in finding the means of extracting and feparating from each other, the different matters which form the vegetable compounds, and have thus become acquainted with what are termed the immediate materials

materials of plants, the firſt queſtions which preſent themſelves to the mind relate to the number and difference of thoſe materials themſelves. We aſk ourſelves by what characters we may know this difference of the materials from each other, and to what number their ſpecies, or rather their genera, amount. Under this double queſtion is comprehended the expoſition of what I term the claſſification and enumeration of the immediate materials. In order to underſtand them well, we muſt revert to the period when chemiſts, informed by the proceſſes of the arts, and eſpecially by the pharmaceutical manipulations, that they might extract from a vegetable, or from the different parts of a vegetable, from its root, its ſtalk, or its leaves, matters different from each other,—and having endeavoured to compare theſe matters with each other, muſt have found that, notwithſtanding the very remarkable difference ſubſiſting between the numerous vegetables that ornament the ſurface of the globe, approximations may however be eſtabliſhed between materials which were ſeparated, frequently even from plants the moſt oppoſite to each other in their ſtructure and their properties.

2. It was then that forming for the firſt time a diſtinct idea of the vegetable compoſition, they diſcovered that ſimilar materials were found in all plants, and they began to form thoſe approximations which I have juſt mentioned. They ſaw that amongſt theſe materials ſome

ſome were liquid, others more or leſs ſolid; ſome ſoluble, others inſoluble in water; ſome had a glutinous conſiſtence, others more or leſs fluidity; that ſome were inflammable, and immiſcible with water; that others had not the ſame inflammability, nor the ſame immiſcibility; in a word, they thus formed ſeries of characters or properties which ſerved to diſtinguiſh thoſe materials from each other. Hence gradually aroſe the diſtinction and the claſſification of what they have ſo long termed immediate principles of plants. The number of theſe principles ſoon increaſed in proportion as the reſearches of chemiſts were multiplied, and as the neceſſity was felt of regularly arranging theſe immediate materials in a methodical order.

3. Suppoſing that we already know, and are able to collect, all the immediate materials, the union of which forms in particular the collective whole of the vegetable; let us imagine, in order to repreſent this whole, and to proceed with order to the vegetable analyſis, all the plants mixed and pounded as it were, forming together only a ſingle maſs produced by vegetation conſidered in its totality, ſubjected afterwards to the different means of extraction which I have deſcribed, and ſeparable into a ſeries of different matters; let us imagine this ſeparation, carried to the point which we cannot paſs without deſtroying the compoſition itſelf, and changing the nature of thoſe different matters. This is the notion which we have

to form of the products of the immediate analysis, or of the immediate materials of vegetables. Each of them is then no longer considered as belonging in particular to such or such a plant, but to the collective whole of vegetable composition, to the whole mass of existing plants. Each of them, of an identical general nature, represents in some sort the same matter existing in all vegetable bodies. For example, the gummous juice and the saccharine juice are the same in all vegetables; in every plant, or part of a plant, from which they have been taken, they are exactly the same: so that with only a few vegetables, provided we choose them in such a manner that they can furnish all the compounds which have hitherto been admitted amongst the immediate materials of plants, we may be considered to proceed in the vegetable analysis in its whole extent.

4. Undoubtedly we cannot yet be certain that we have arrived at the complete discovery of all the immediate materials of vegetables: that we have extracted and know them all, that there remains nothing more to be discovered amongst these materials;—such an assertion would even be repelled by the eight or ten new principles, acids and others, that have been discovered within these twenty years past, which have been added to the catalogue of those which had before been known and distinguished. Undoubtedly this catalogue, so far from being completed at the present day, is perhaps incapable

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of ever being ſo, nor can we confine within any limits what ſtill remains to be done in this reſpect by the human intellect. However, it is neceſſary to eſtabliſh a kind of boundary in the preſent ſtate of our knowledge; it is neceſſary while conſidering the ſcience at the point of perfection to which it has arrived, even were it only in order to draw up the catalogue of the notions that have been acquired, to preſent an enumeration of theſe materials; and it is in order to preſent this enumeration that the moſt able and moſt ingenious chemiſts have particularly occupied themſelves for ſome years paſt.

5. Some have taken for the baſis of the claſſification which they have adopted, the mode itſelf in which they were extracted, or the order of analyſis. Thus Rouelle, in his table of the vegetable kingdom, has treated ſucceſſively of the analyſis of plants, or of the materials ſeparated by a gentle or a violent fire, by water, by fermentation, and by alcohol; others have followed a method relative to the order of the diſſection of the plants, or of the natural and ſimple extraction of their materials with reſpect to the ſtructure or the different vaſcular ſyſtems of vegetables: this is the courſe which Bucquet has followed. Some others have founded their principal diviſions upon the properties made uſe of in common life, or in the arts. Moſt have conſidered them in no other point of view than that of medicinal preparations, and have followed only a pharma-

pharmaceutical order. A very great number have ſimply treated of theſe materials according to the ſeries of different operations to which they are ſubjected. None of theſe methods has yet been ſyſtematic, and founded upon a compariſon of the properties of the different immediate materials of vegetables.

6. When we conſider in the moſt general manner, or under the moſt extenſive point of view, the different modes of claſſifying the products, or immediate materials of plants, we find that only four principal methods of diviſion or of claſſification can be admitted amongſt them. And in fact we may follow firſt the anatomical order, and examine ſucceſſively the materials of the roots, the bark, the ſtems, the woods, the leaves, the flowers, the fruits and the ſeeds, or even directing our attention to the interior ſtructure, thoſe of the common, the proper, the utricular, and the cellular veſſels. But this firſt order repreſents inceſſantly the ſame objects which we ſhould thus be obliged inceſſantly to reconſider; for each of the parts of plants, though very different in their ſtructure and reſpective ſituations, frequently contain matters analogous to thoſe which are contained in others, and it is evident that the mere ſeat or place does not indicate a difference ſufficiently conſtant or ſufficiently marked to afford a certain baſis for the diſtinctions to be eſtabliſhed between thoſe different materials.

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We may choofe for this bafis the properties themfelves of the materials, diftinguifhing them into nutritive or alimentary, medicinal, combuftible, textile, fermentefcible, folid and permanent, &c. But this fecond method, which may have its advantages in the applications of the fcience, has however too few relations with the philofophical views, and the individual progrefs of the latter, for it to be capable of affording the advantage which is fought in it.

7. A third method of diftinction between thefe feveral vegetable bodies or compounds might be founded upon the really chemical characters, or the intimate properties by which they are feparated and known. For example, fome immediate materials are mucous, others are faccharine, fome are acid, fome oily and inflammable; fome are coloured, fome folid and infoluble, and fome approach to the animal fubftances. We might even combine with this firft divifion that which confiders the materials with refpect to their ftate or confiftence as liquid, foft, fibrous, glutinous, lamellated, pulverulent; thofe alfo which diftinguifh them by their tafte into fweet and infipid, fweet and and faccharine, acid, acerb, bitter, acrid; by their fmell, into odorant, inodorous, fetid, aromatic. This method of difpofing the materials of vegetables is one of the moft ufeful and moft philofophical; it depends upon the chemical properties on the one hand, whilft on the other it leads to the knowledge of the advantageous

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or uſeful properties: it therefore in every reſpect merits the preference beyond the two firſt, and it will ſoon be ſeen that it is the method to which I approach the neareſt.

8. Laſtly, the fourth method, the moſt philoſophical of all, which ſuppoſes the greateſt advancement in the ſcience, and which can yet be preſented only in idea or expectation,—which, in a word, is far from being able to be brought to that point of perfection which it may hereafter attain, and which will then be followed with one accord by all who ſhall occupy themſelves with the ſtudy of nature, is that which, founding itſelf upon the progreſs of vegetation, of vegetative chemiſtry, ſhall arrange the immediate materials according to the order of their ſucceſſive formation in plants, and diſpoſe theſe materials according to time and the periods of their appearance and their creation. In order to comprehend this laſt diviſion perfectly, I muſt here mention, that notwithſtanding the little real progreſs which chemical ſcience has yet made in the knowledge of the phenomena of the growth, and of the particular vitality of the plants, it has however already elevated itſelf ſo much in its conceptions and experiments, as to know that the immediate materials of vegetables are formed ſucceſſively, at different periods of vegetation, that each of them belongs in ſome meaſure to one of theſe periods; for example, the mucous ſap and the mucilage to the firſt periods of vegetation,

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the faccharine fubftance to the germination and the maturation of the fruits, the ligneous fubftance to the growth and frutefcence, the oil and the wax to the fructification; that all thefe different materials are only progreffive modifications of the fame matter, of a fingle primitive, ternary or quaternary compound, which feems to commence with the fappy gum, and to finifh with the wood and bark; and that by thus inveftigating, either from an attentive examination of the phenomena of vegetation themfelves, or by a comparative analyfis of the different vegetable materials, an analyfis placed in fome meafure at the other extremity of this philofophic chain, we fhall be able hereafter to find out the order, the fucceffion, the epocha of the formation of each immediate vegetable matter.

9. It is by combining thefe two bafes, as far as the ftate of the fcience has permitted me, the chemical characters on the one hand, and the fucceffion or the relative period of the formation on the other, that I fhall here give the claffification and the enumeration of the immediate materials of vegetables, the number of which I reduce to twenty different matters, viz.

A. Sap.
B. Mucous matter.
C. Sugar.
D. Vegetable albumen.
E. Vegetable acid or acids.
F. Extractive.
G. Tanin.
H. Starch.

I. Gluten.

I. Gluten.
K. Colouring matter.
L. Fixed oil.
M. Vegetable wax.
N. Vegetable oil.
O. Camphor.
P. Refin.
Q. Gum refin.
R. Balfam.
S. Caoutchouc.
T. Ligneous matter.
U. Suber.

10. I muft obferve, that of the twenty materials which I have juft enumerated, the fix firft are frequently diffolved in the water of the plant, circulating with the fap, or are fufceptible of diffolving in the water which we add to them; the three following, the ftarch, the gluten, and the colouring matters, have a pulverulent or lamellated form; the oily fubftances, from the fixed oil to caoutchouc inclufively, inflammable and infoluble in water, are inclofed in particular cells or veffels; and the two laft, the ligneous fubftance and the fuber, form the folid infoluble part, the common fupport and integument of all the parts of vegetables. Of thefe twenty fubftances, there are at leaft four which have been miftaken by the chemifts before me, or which they have not diftinguifhed from the other materials, or have neglected to ftudy as particular products; thefe are the albumen, the wax, the ligneous matter, and the fuber. Each of thefe immediate materials,

terials, the properties of which I am about to examine, ought to be confidered as a peculiar genus of vegetable compounds, to which the fpecies or varieties will be referred, according to the flight differences they poffefs in the different vegetables: in examining each of thefe bodies, I fhall confider fucceffively and in the fame order for all.

A. The feat or fituation which it occupies.
B. The proceffes for its extraction.
C. Its chemical properties.
D. Its chemical products.
E. Its fpecies or varieties.
F. Its ufes.

Article IV.

Of the firft of the immediate Materials of Vegetables, namely the Sap.

A. *Seat.*

1. I CONSIDER the fap as the firft of the immediate materials of vegetables, becaufe this is the liquid which in fact fhows itfelf the firft in vegetation. When the motion which takes place in trees and plants at the firft warmth of fpring, and after the long fleep into which they have been funk by the cold of the winter, begins to dilate their buds, and caufe their leaves to

to unfold themſelves, the ſap which ſwells the common veſſels, and perhaps even at this period all the orders of veſſels of theſe organized bodies, opens as it were, by its progreſs, the ſcene of vegetation; it aſcends from the root into the ſtem, and from this by the medullary prolongations under the bark, and to all the extremities of the trees and plants which it dilates, which it develops, and which cauſes it to grow with greater or leſs activity. In this plethora, this general turgeſcence of the veſſels of theſe bodies, ſome parts of their ſides are unable to reſiſt the diſtenſion which they experience; fiſſures, crevices are formed; the ſap opens itſelf a vent on all ſides, and flows out with more or leſs force, either by the cortical fiſſures, or in the vicinity of the buds, or at the extremity of the ſtalks.

B. *Extraction.*

2. If we cut young branches at this period of the motion of the ſap, and place the extremity that has been cut in a bottle, there iſſues out a quantity of this liquid ſufficient to enable us to obtain nearly half a kilogramme (from twelve to ſixteen ounces) in twenty-four hours. If we pierce the trunk of the tree horizontally with an auger, there runs out a ſufficiency to enable us to collect quantities uſeful in ſeveral of the arts, and eſpecially in the preparation of an acidulous and vinous liquor, much employed and very uſeful in ſeveral of the foreſts of Germany.

many. In America, the ſap of ſeveral kinds of maple is obtained by the ſame proceſs, in order to extract from it ſugar ſimilar to that which is furniſhed by the ſpecies of gramen cultivated in the colonies of the Europeans in America. It was long ago known, from theſe two kinds of experiments upon a very large ſcale, that the ſap of trees contains ſaccharine matter, and that it is ſuſceptible of fermenting or yielding a vinous liquor; but theſe firſt notions were very remote from the remarkable diſcoveries that have been made ſome years ago upon this ſubject by Citizens Vauquelin and Deyeux.

C. *Phyſical Properties.*

3. Sap is a limpid and colourleſs liquid, which was long believed to be pure water, and which on that account was denominated *tears*. Its taſte is ſometimes inſipid, ſlightly ſaline, ſometimes ſweet, almoſt always briſkly acid or acidulous. Immediately after it has been extracted from the trees, it contains no foreign ſubſtance, no ſolid matter, no flakes, and it has no colour; it often froths much upon the ſlighteſt agitation. When we pierce, or even when we ſaw trees as far as their centre, and apply the ear cloſe to the cut of the ſaw, we hear a crackling or ruſtling noiſe, perfectly ſimilar to that of bubbles of air, when, by the effect of compreſſion, they paſs through a liquid, from which they eſcape with difficulty. When kept for ſome time in a well-cloſed

closed bottle, a spontaneous effervescence takes place, which pushes out the cork, as is done by fermenting wine: it then becomes strongly acid, powerfully reddens the blue vegetable colours, and is turbid in a more or less sensible degree. Its consistence is never mucous or ropy; on the contrary, it is very light and liquid. It cannot therefore be confounded with any of the materials that are to be examined after it, because it has none of their apparent characters.

D. *Chemical Properties.*

4. Sap exposed to the fire becomes filled with bubbles, swells and readily yields carbonic acid gas; when it is evaporated, it diffuses a strong smell of vinegar; it affords an extract of a beautiful red colour mixed with tanin; the latter exists in the sap of the oak and the beech; it sometimes affords a small quantity of albumen, but then it contains no tanin; we find saccharine matter in it, especially in that of the maple and the birch; it becomes brown during its evaporation; it also affords carbonate of ammonia when it is distilled to dryness. Amongst its products we distinguish vinegar, which is the more abundant, the longer it has been kept after its extraction from the trees, before the period at which it is subjected to the action of the fire. In its coal we find carbonate of pot-ash, carbonate of lime, muriate and sulphate of pot-ash. These are the phenomenona described by Citizens Deyeux and Vauquelin, after the treatment of the sap by the fire.

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5. When we leave ſap expoſed to the air, it aſſumes the yellow and the brown colour; it depoſits many flakes which Citizen Deyeux believes to be a kind of vegeto-animal or glutinous ſubſtance, held in ſolution by the acetous acid. It ſoon ferments, yields a great quantity of carbonic acid gas, becomes more intenſely ſour, and forms a kind of vinous and acidulous liquor, from which we may extract alcohol by diſtillation. If we leave it for a longer time to become altered in the air, it aſſumes a fetid ſmell, becomes very brown, depoſits a filamentous and gluey mucilage blackiſh at its ſurface; at laſt it becomes ammoniacal. Thus it is ſuſceptible of the three fermentations, the vinous, the acid, and the ammoniacal or putrid,

6. Sap mixes in all proportions with water, which dilutes, extends, and diſſolves it, when it is thick and viſcous, which alſo facilitates the ſeparation of its different flakes, and the motions of ſpontaneous alteration, which the different materials of which it conſiſts are capable of experiencing. It only acquires leſs colour after having been diluted with water.

7. The powerful acids expel from it the carbonic and the acetous acids, and form calcareous ſalts with a baſe of pot-aſh, which are found by evaporating the ſaps to which they have been added. They alſo ſeparate from them concrete flakes, at leaſt in ſeveral kinds of ſaps. When they are concentrated, particularly the ſulphuric acid they burn and blacken them, by

carbonating the extractive and glutinous materials which they contain. The nitric acid converts their extracts into mucous and oxalic acids; the latter ſhows that lime exiſts in them.

8. The alkalis combine quickly and eaſily with ſap; they ſaturate the exceſs of acid, which it almoſt always contains; they prevent its depoſition and precipitation ſo quickly as it would do ſpontaneouſly; they retain in ſolution the tanin, the extracts, or the vegeto-animal ſubſtance which it ſometimes appears to contain.

9. The ſalts, properly ſo called, merely diſſolve the materials of ſap, check its fermentation, preſerve its integrity without cauſing it to undergo any alteration, and without being able to aſſiſt in rendering us acquainted with its principles.

10. The ſame is the caſe with the metals and metallic ſolutions; they cannot afford us much light with reſpect to the nature of ſap: the firſt become coloured or diſſolved; the ſecond ſometimes unite with the acids which are contained in it, and ſaturate them; metallic ſolutions are entirely precipitated in it, either by the extractive matters, or by the acetites which form part of this vegetable liquid, and act upon the metallic ſalts by double elective attraction.

11. Citizen Deyeux has concluded from his experiments that ſap is a compound liquor, containing calcareous acetite and a vegeto-animal matter united with the acetous acid: it is to this

this matter he attributes the ſpontaneous precipitation of the ſaps in the air, the formation of the ammonia, and the ſmell of burned rope, which is diffuſed by the reſiduum of its evaporation when placed upon ignited coals. He compares this ſubſtance with the glutinous matter of cheeſe, equally ſoluble by the acetous acid, and forming ammonia.

12. After the experiments of Citizen Deyeux, made in Germinal and Floreal of the year 4, Citizen Vauquelin inſtituted a ſimilar inquiry reſpecting the ſaps in the ſame ſeaſon of the year 5. The firſt had examined the ſap of the yoke-elm and the vine; the ſecond has analyzed thoſe of the elm, the birch, the beech, and the yoke-elm: in all he has conſtantly found acetite of pot-aſh and acetite of lime, ſometimes acetous acid in exceſs, ſometimes carbonate of lime and carbonic acid, a ſaccharine matter, tanin, gallic acid, two very high-coloured extracts; the one ſoluble in alcohol, the other only ſoluble in water. Hence he concludes, that all the ſaps are acid, that they contain either acetous or carbonic acid, or both at once; that part of the acetous acid is combined in them with the pot-aſh, and the other with lime: that the ſaps which contain acetous acid in a free ſtate contain no carbonic acid, neither free nor united with a baſe, but that both acids are often combined with theſe two baſes in the ſame ſappy liquor; that all the ſaps contain vegetable matters, which become coloured in

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the air, and by the effects of heat; that they all yield ammonia by diſtillation; that muriate and ſulphate of pot-aſh are alſo found in all.

13. It is eaſy to conceive, from the intereſting diſcoveries of the two French chemiſts, that ſap is a very much compounded liquor, in a certain degree comparable with blood, containing a large part of the materials of plants, diſpoſed to form them all, according to the different places which it is deſtined to traverſe, or in which it reſides. I ſhall ſhow hereafter, that a portion of the ſubſtances which it holds in ſolution, proceed from the ſoil itſelf in which the roots are ſituated.

E. *Species and Varieties.*

14. We are yet far from having examined a ſufficient number of ſpecies or varieties of ſaps, to be able to draw general and certain concluſions with reſpect to their comparative properties. Hitherto only the ſaps of the vine, the elm, the birch, the beech, the oak, and the yoke-elm, have been analyzed. The following is what already reſults reſpecting the difference of thoſe liquors, according to the comparative analyſis that has been made of them.

The ſaps of the oak and the beech contain gallic acid and tanin; they cannot at the ſame time contain animal ſubſtance, becauſe this principle would precipitate it. Accordingly, by mixing theſe ſaps with white of egg, with a ſolution of

 glue,

glue, and with a ſolution of the gluten of flour in vinegar, Citizen Vauquelin has obtained a precipitate of tanned animal matter. After having ſeparated this precipitate, the ſupernatant liquor contained gallic acid, acetites of pot-aſh and of lime, and two extracts: the one ſoluble in alcohol; the other mucilaginous, inſoluble in this liquor, and capable of being converted into mucous and oxalic acids by the nitric acid.

The ſaps of the birch and the maple contain a ſufficient quantity of ſaccharine matter for it to be extracted with advantage, and for their forming a kind of vinous liquid by the fermentation which they are capable of undergoing.

Finally, there are ſeveral ſaps which contain a remarkable quantity of nitrate of pot-aſh.

It would be ſuperfluous here to obſerve, how uſeful and intereſting it would be to analyze the ſaps of different trees; what intereſting reſults might be obtained from this analyſis, for the completion of our chemical knowledge reſpecting the vegetable compounds, and afterwards for vegetable phyſics.

F. *Uſes.*

15. It is not difficult to ſee that the uſe of the ſap in the economy of nature is to ſerve the purpoſes of vegetation by developing the parts of plants, and the formation of the different immediate materials of plants; that this liquid

is the principal ſource of all the vegetable liquors, and even of their ſolid materials.

16. Though it cannot be ſaid that the ſaps are real food for man, thoſe which contain ſugar may to a certain degree anſwer this purpoſe. They are uſed for preparing drinks, vinous, ſtrengthening and refreſhing liquors, which are highly eſteemed by phyſicians, and employed in many parts of Germany in the treatment of acute and febrile diſeaſes. Beſides which, the uſe which is made in North America of the ſap of the maple, in order to extract ſugar from it, which affords a ſubſtitute for that of the African or American ſugar-canes, proves that we may at leaſt rank this liquor in the claſs of auxiliary foods.

Addition to the Article on Sap, relative to the expreſſed Juice of Plants.

1. WE may rank after the ſap, and even conſider as a ſpecies of this liquid, that which is termed the juice of plants, and which is extracted, either for medicinal uſe in the laboratories of pharmacy, or as a matter uſeful in the arts in ſome manufactories. In fact, theſe ſaps, from whatever plants we may take them, or from whatever freſh vegetable we may extract them, are compoſed in a great meaſure of ſap; for by pounding theſe organized bodies in a mortar, we break and open in all their conti-

nuities

nuities the common or ſap-veſſels which are filled with it. The proceſs for obtaining them is extremely ſimple. The freſh, green, and ſucculent plants are chopped ſmall, or pounded in a mortar of marble or wood; the latter is eſpecially preferred when the operation is to be performed upon acid herbs; they are moulded with the hand into a kind of ball, which is forcibly preſſed, or they are incloſed in a piece of linen, which is tied together, and afterwards put into a preſs; ſometimes, in order to cauſe the juice which they contain to flow freely, water is added, particularly when the plants are too dry, or when they are too viſcous.

2. As by this manipulation we obtain juices very much coloured, very turbid, and much charged with the fibrous parenchyma of the plants, which the peſtle or the cutting inſtruments have lacerated in all their points, it is evident that theſe juices are far from being the pure liquid which diſtended their veſſels. They not only contain ſap, but they are alſo mixed with the liquids incloſed in the proper veſſels, the mucilages ſeparated from the utricles and the cortical layers, with fecula or fibrous parts, more or leſs minute, torn away from the texture of the vegetable itſelf. Of theſe different matters thus added to the ſap, ſome, being diſſolved in water, cannot be ſeparated from thoſe which belong to the ſap itſelf, except by chemical proceſſes more or leſs complicated; others, being only diſſeminated and

and fuſpended in the liquid, and conſiſting of ſolid molecules, are much more eaſy to be precipitated from it.

3. The ſeparation of the latter, which deſtroys the tranſparency and purity of the expreſſed juices of plants, is eſpecially recommended in the laboratories of pharmacy, in order to effect what is called defecation: reſt alone is frequently ſufficient to anſwer this purpoſe. When the juice is very fluid, the fibrous particles of the fecula approach to each other, collect together, depoſit themſelves in the form of flakes more or leſs green at the bottom of the liquid, which only requires to be decanted in order to have it ſufficiently pure. This ſimple proceſs, it is true, can only be uſed in thoſe caſes where the juice is not ſuſceptible of ſpontaneous change, where it contains no volatile and odorous principle which it is neceſſary to preſerve, in order that it may enjoy all its medicinal properties: for the ſpontaneous precipitation, and the complete depoſition of the fecula, frequently require ſeveral hours; and this time is ſometimes ſufficient for an interior motion or ſome alteration to eſtabliſh itſelf in the juices, eſpecially when the temperature is elevated above fifteen degrees in the atmoſphere.

4. Sometimes filtration through paper without ſize is had recourſe to, in order to ſeparate the fecula from the juices. This proceſs is practiſed only for the moſt fluid and lighteſt juices, that are required to be purified quickly; ſuch

ſuch as thoſe of houſe-leek, purſlain, lettuce, ſuccory, &c. In other circumſtances, eſpecially when we have to treat juices a little viſcid, mucilaginous, thick, and containing nothing volatile, as the juices of borage, bugloſs, pellitory, or nettles, we mix them with a little white of egg and water, then ſtir them, cauſe them to boil for a moment, and filtrate them when they have cooled. The albumen, as it coagulates, forms a reticular ſubſtance, which, in its aſcent, detains and ſeparates all the feculent particles that troubled the liquid. But the heat of the ebullition gives them a much deeper colour than they had before, and alters them ſenſibly; ſo that this is not merely a defecating, but an actually decompoſing proceſs.

5. There are ſome juices whoſe alterability is ſo great with reſpect to the odorous matter which they contain, and which it is neceſſary to preſerve for the medicinal uſe for which they are deſtined, that we have been obliged to ſeek means of ſeparating the fecula with ſufficient celerity not to leave them time to become altered, and gentle enough not to change or affect their intimate nature. Such is the proceſs employed for defecating the juices of creſſes, cochlearia, beccabenga, and all the antiſcorbutic juices which have an acrid and pungent odour. It conſiſts in putting them into a matraſs or bottle, the mouth of which is covered with a piece of wet parchment perforated with ſeveral punctures with a pin,

a pin, plunging this bottle into another veſſel filled with boiling water, and ſuffering it to remain for ſome minutes in this bath; we ſoon ſee its fecula collect in concrete flakes, which gradually depoſit themſelves at the bottom; we then filtrate the liquid, which is found to have loſt nothing of its ſmell or of its properties. This proceſs is founded upon the nature of the fecula, which appears to approach to that of albumen or glutinous matter, and as ſuch to be coagulated by the action of the fire, and afterwards ceaſe to be capable of being ſuſpended in the liquid.

Laſtly, another means is ſometimes employed, in order to defecate the juices of plants, by adding to them vegetable acids, lemon-juice, vinegar, ſometimes even wine, and eſpecially white wine: this practice is eſpecially recommended in ſome foreign diſpenſaries. Indeed, it is only propoſed for the antiſcorbutic juices, with which we thus join a ſubſtance that can only augment their energy, and add to their medicinal virtues; it is alſo founded upon the albuminous and coagulable property of the feculent matter, It is very evident that if theſe juices contain glutinous matter, this principle muſt remain in part diſſolved in the defecating acid.

7. The purified or depurated juices of plants have great analogy with ſap; like it, they frequently contain a free acid, and almoſt always acetites, either of pot-aſh, or of lime; like it, they

they are coloured by the action of the fire and the air; like it, they precipitate coloured flakes by the addition of oxigenated muriatic acid; like it, finally, they yield by evaporation, red or brown extractive matters. They, however, differ from it in the circumstance that saccharine matter is rarely found in them, and never tanin or gallic acid. In general, the two latter materials are only met with in the saps of the trees; they have the most intimate relation with the ligueous substance; they constitute either the source or the depositary of this solid substance. The juices of plants differ also from sap in the circumstance that we frequently find in them a greater or less quantity of gummy mucilage, which exists but very rarely or never in the latter; and we see that these differences depend either upon those of the young, succulent, herbaceous plants, from which the juices are expressed, or upon the manner itself that is employed for obtaining them, the violent pressure which is practised. Citizen Vauquelin has lately found the malate of lime to exist in considerable abundance in the juices of the houseleek (*sempervivum tectorum*), and of several species of *sedum*.

8. In a chemical point of view, the expressed juices belong much more nearly than the saps to the history of the extract, or extractive in general. When we evaporate the former liquids by the action of the fire, in order to obtain what are termed *inspissated juices*, such as the juice

juice of borage, of the elaterium or wild gourd, the juice of the acacia, that of hypociftus, of floes, opium, &c. we actually prepare a kind of extracts or extractive mixtures, confiderably refembling thofe that are obtained by the action of water upon the dry vegetable fubftances. I fhall fpeak of them again under this relation in one of the fubfequent articles.

Article V.

Of the fecond of the immediate Materials of Vegetables, of the Mucus, or the Mucilages and Gums.

A. *Seat.*

1. MUCUS, mucous fubftance, or mucilage, fo eafily diftinguifhable by its vifcofity, its thick and gluey confiftence, its faint or infipid tafte is found in many vegetable parts different from each other: it is one of the moft diffufed of the immediate materials of vegetables, and which the work of vegetation feems to form the moft eafily and frequently. It is known in all the organs of plants, when by pounding them their particles adhere to one another as it were, in a pulp, when all the fubftances that are brought into contact with them, ftick and adhere to them, when they join with this firft property an infipidity, or faint tafte more or lefs peculiar, and an inodorous quality.

2. It

2. It is found in a great many roots, fuch as thofe of the mallows, confolida, the lily, &c. and in general in thofe of young plants, in fuch as do not naturally become ligneous, or thofe which only become fo very late. It exifts in the ftalks, and efpecially under the epidermis, and between the laft cortical layers, which it moiftens, through which it frequently forms itfelf a vent, in order to run out, as we fo often fee in the fruit-trees, efpecially in thofe that produce ftone-fruits. It is alfo found in the leaves of a great number of vegetables, almoft at all periods of vegetation, and in all towards the commencement of their opening and unfolding themfelves. This we may afcertain at this period, by crufhing between the fingers the delicate texture of the leaves, which ftrongly adheres to the fkin; it frequently accompanies the pulpy or parenchymatous texture of the fruits, always the integuments of the feeds, fometimes the exterior, fometimes the interior. Before the cotyledons are formed, and have become dry and farinaceous, they exift under the gelatinous, tranfparent, and vifcous form of a mucilaginous fubftance.

3. Very frequently the mucus is intimately mixed, or even combined with fome other immediate principles of vegetables, efpecially with fugar and the acids, as we find to be the cafe in moft of the fruits from which the juice is eafily extracted; fometimes with the amilaceous fecula or ftarch, with the fixed oils,

with

with the refins, or the gum-refins. When it is alone and infulated, it frequently forms a real plethora in the different organs of the vegetables, and particularly between the external laminæ of the cortical layers below the epidermis, efpecially towards the extremities of the branches, of the petioles, of the peduncules of the flowers and fruit; it is moft frequently at thofe points where there are a great number of interruptions and fiffures in the continuity of the epidermis, that the mucus iffues and runs out on the furface of trees, which frequently contain a large quantity of it.

B. *Extraction.*

4. When the fuper-abundance of the mucous juice violently diftends the veffels of trees (for the fame phenomenon is not obferved in the herbaceous plants) thofe veffels become ruptured, and the mucilage, more or lefs thick, vifcous, and gluey, iffues in drops which fpeedily dry in the air. Then the furface of thefe trees, and efpecially the points of the infertion of the branches, the twigs, the petioles, the leaves, the peduncles, the fruits, and the fiffures which are fometimes formed upon them, become covered with thefe drops of mucus, which gradually accumulating and drying in the air, give rife to tears, tranfparent round irregular bodies, fometimes to ftalactiform elongations, to a kind of blades or

 ribbands,

ribbands, ſmooth or ſtriated, white, yellowiſh, reddiſh or brown, which are known and collected by the name of *gums*. Thus the traveller, who journeys through the interior of Africa, finds every where in his courſe the tears of the gum Arabic, which hang from the twigs of the acacia, or *mimoſa nilotica*, which grows in abundance in thoſe countries. Thus in our orchards and gardens, the apricot, the peach, the plumb, the cherry, the almond-trees become covered at the beginning of the ſummer with gummy tears, which are ſeparated from them, and are known in commerce by the name of gum of the country *(gummi noſtras)*.

5. When the gummiferous trees, eſpecially the old, are ſurcharged with this mucous ſubſtance which ſwells their veſſels, longitudinal orifices, in the direction of the axis of the trees, are ſometimes made in their bark with ſucceſs, for their preſervation and health. In this caſe, the gummy juice iſſues out more or leſs abundantly by theſe inciſions, and may be collected in large quantities. As nature furniſhes it in ſufficient abundance for all the uſes to which this ſubſtance is appropriated, this operation is not performed for the purpoſe of obtaining it, but merely for the relief of the trees.

6. When the mucus, in the form of a thick and viſcous liquid, is intimately or profoundly incloſed in the organs of vegetables, as in the roots, &c. when it is applied in dry and poliſhed layers to the ſurface of the ſhining or gloſſy ſeeds,

feeds, fuch as thofe of flax; when it exifts in thin, but not dry layers, under this integument of the feeds, as in all thofe of the cucurbitaceous plants, the pippin-fruits, the quince, &c. we can neither extract it by trituration nor by preffure. In this cafe we dilute or even diffolve it with the aid of hot or boiling water; and in this ftate it is more efpecially called *mucilage.* Thus the juices of fome young mucous and gluey leaves, when they have been crufhed and reduced into a pulp, efpecially fuch as thofe of borage, of buglofs, of fcabiofa, &c. cannot eafily run out, without water being added previous to their expreffion, on account of the large quantity of mucilage which accompanies their fap, and which we are obliged to extract together with it.

7. The mucilage frequently being combined with a vegetable acid, and diffolved or rendered fluid by this acid, runs out together with it, and affords a four juice, poffeffing a greater or lefs degree of vifcofity. Such are the juices of the lemon, the orange, the currant, the ftrawberry, the rafpberry, the cherry, the plumb, the peach, the apple, the barberry, the fervice, the grape, &c. &c. we unite their two conftituent materials, ftill more intimately together, prevent their feparation, and impede their alteration, by diffolving in them a fufficient quantity of fugar, as is done in the preparations known by the name of *conferves.* But if, inftead of following this practice, we leave thefe juices to themfelves after having

having extracted them from the fruits, at the end of ſome hours, and eſpecially with the contact of the air, they depoſit the mucilage which they contain in a gelatinous form; we may ſeparate them by placing theſe liquids which have become thick by depoſition, upon a cloſe and fine ſieve, which ſuffers the more liquid acid part gradually to run out, and detains the mucous juice. This is waſhed with a little pure water, in order to ſeparate the portion of acid which it ſtill contains. Frequently it retains a ſmall quantity of colouring matter, which gives it a yellowiſh, fawn, or roſe-coloured tinge. By drying, it aſſumes more colour, diminiſhes in its volume, preſerves its tranſparence, and becomes dry and brittle like a real gum.

8. There are ſome caſes in which the mucus accompanies the oils; thoſe that are termed fixed are particularly impregnated with it: it then forms what Scheele terms the *mild principle* of the oils. It is not ſeparated from them without much difficulty; ſometimes it is ſpontaneouſly precipitated from them by reſt, and preſents itſelf at the bottom of theſe liquids as a flaky depoſition. It always impedes their combuſtibility, and contributes to form the knobs on the wicks of lamps; a more or leſs abundant portion of it is depoſited when we heat theſe oils, and a ſort of precipitate is formed, which impairs their tranſparency, and renders them viſcid. It is alſo ſeparated from theſe inflammable bodies by the action of ſeveral re-agents, and

eſpecially

eſpecially by that of the metallic oxides, as Scheele has obſerved, and as I ſhall ſhow in the hiſtory of the fixed oils.

C. *Phyſical Properties.*

9. The mucus exiſts in three principal ſtates, either in or out of the vegetables. It is ſolid or concrete and friable, and in fragments or pieces more or leſs large; it is almoſt always ſpheroidal on the outſide of the trees; it is either ſprinkled in the form of powder, or ſpread in thin layers upon the ſurface of a great number of ſeeds: laſtly, it is in the ſtate of a viſcid, gluey, thick liquid in the roots, the ſtalks, the internal part of the ſeeds. Its liquid ſtate varies greatly in denſity, according to a multitude of circumſtances, which tend to thicken or to diſſolve it, eſpecially according to the dryneſs or moiſture of the weather, according to the proportion of water which the plants are capable of abſorbing.

10. The viſcid nature of the ſoft mucous ſubſtance, the kind of glutinous or agglutinating conſiſtence which it poſſeſſes without being elaſtic, the tendency to adhere which ſubſiſts between its own particles, and communicates itſelf to the different ſurfaces between which it is placed, joined with the brittle and pulverizable property which it poſſeſſes when ſufficiently dry and gummy, prove that it owes the firſt of thoſe characters to the adheſion which

which its particles contract with water, and their attraction for this liquid.

11. Mucus when very pure is colourless. It is clear and transparent like water. It never becomes coloured, except in consequence of its having undergone a first degree of alteration in its intimate composition, or being mixed with some foreign substance of a colouring nature. It has no taste properly so called, it is only sweetish and insipid. Every taste besides this, whether astringent or saccharine, or bitter, proceeds from some foreign substance associated with it. It is also perfectly inodorous: when, reduced into powder or into vapour by the means of boiling water, it is introduced into the nostrils, it excites only a very slight impression, which would scarcely be sufficient to apprize us of its presence without the aid of the other senses, of the sight or the touch. Its specific gravity, from the purest to the most mixed gum, is to that of water, as 13,161, or 14,817 to 10,000.

D. *Chemical Properties.*

12. Mucus, exposed dry or in the state of gum, to an open fire, or with the contact of the air, is fused, swells, becomes yellow, red, and brown; is reduced to coal, augmenting greatly in its volume, and exhales successively, during this alteration, an aqueous vapour, a more dense smoke of a pungent sour smell, which is not unpleasant; it produces only some light flames:

flames: at the termination of this action it leaves a light and very voluminous coal. When distilled in an apparatus properly disposed and provided with pneumato-chemical tubes, it affords water, a reddish acid liquor, some drops of brown oil, carbonic acid gas, a little carbonated hidrogen gas, and a coal much more bulky and of a different form from the gum, of a single piece when this has been introduced in powder or in small fragments into the crucible. The water disengaged has been composed in a direct way by the combination of the hidrogen and the oxigen of the gum, and was not contained in this body. The oil, which is in very small quantity, is the product of a portion of carbon and hidrogen, united and sublimed together; the carbonic acid gas proceeds from a portion of the carbon burned separately by the oxigen at a high temperature, and perhaps even from a part of the water already formed, decomposed by the carbon, set free, and brought to a red heat: which seems to be proved by the carbonated hidrogen gas which accompanies it, and which, like the first gas, is not developed, but at last, and when the action of the fire is the strongest. The coal, which forms about a fifth part of the gum, and which remains in the retort, is light, porous, easy to be burned; it yields but very little ashes, in which are found some traces of pot-ash, a small quantity of carbonate, and of phosphate of lime.

13. With respect to the acid, one of the new

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and moſt remarkable products of the decompoſition of mucus, it is a compound formed at the expenſe of a portion of the carbon, the hidrogen, and the oxigen of the gum; a compound which was not contained in this natural inſipid product, that does not redden the blue colours. This acid is a creation of the fire. As it will ſeveral times preſent itſelf in the examination of the immediate materials of vegetables, and as it is not otherwiſe found amongſt the natural products of plants, it is neceſſary here to explain what is known of its properties or characters. The firſt chemiſts who have mentioned it knew it only by the name of ſpirit, or acid phlegm of gum; and Citizen Guyton termed it ſirupous acid, becauſe it is alſo a product of the diſtillation of ſyrup, and as he had obtained it in conſiderable abundance from diſtilled ſugar. Laſtly, in order to generalize its nature, its formation, and its origin, it has been termed pyromucous acid. He has not yet ſtudied all its combinations: however, what has already been collected reſpecting its properties is ſufficient to diſtinguiſh and characterize it. Chemiſts have erroneouſly believed it to exiſt ready formed in the gums; they have admitted it in a ſaponaceous combination with oil, and neverthele ſs there exiſts as little oil as acid ready formed in theſe vegetable compounds.

14. The pyromucous acid is always liquid; it is neither more nor leſs volatile than water; it

it does not abandon it when it is diſtilled; we can neither obtain it in the gaſeous nor in the ſolid form. It has a pungent, ſour, and empyreumatic taſte; it has a ſmell analogous to that of radiſhes, or of roaſted bitter almonds: in this reſpect it in ſome meaſure reſembles the pruſſic acid. At a high temperature it is decompoſed into carbonic acid and water; it always leaves a coaly ſtain when it is diſtilled in a retort. When we expoſe it to the froſt, it becomes concentrated on account of the portion of water which ſeparates from it. It produces upon the ſkin an orange-coloured or reddiſh ſtain, which diſappears only with the cuticle. With lime it forms a calcareous pyromucite of conſiderable ſolubility. Its ſaline combinations are not known; we only know that they differ from all the others. It diſengages the carbonic acid from all its baſes, and produces a lively efferveſcence with all the carbonates. It attacks neither platina, nor gold, nor ſilver, nor mercury; it corrodes and oxides copper, iron, lead, and tin; it cryſtallizes with the oxide of lead and the oxide of iron. The order of its elective attractions, according to Citizen Guyton, is the following: pot-aſh, ſoda, barites, lime, magneſia, ammonia, alumine, the metallic oxides, water and alcohol. We ſee from this ſhort expoſition, that the properties of this pyromucous acid are as yet ſcarcely known, and that what has been determined concerning them is

merely

merely ſufficient to ſhow that it differs from all thoſe that have hitherto been diſcovered; no uſe is made of it.

15. The gums are abſolutely inalterable by the air; the mucilage only thickens and becomes gummy. Water eaſily diſſolves the mucus, which gives it a great degree of viſcidity, as every one knows. Heat greatly aids the action of the water, and enables it to diſſolve more quickly a larger quantity of gum; when too ſtrong or too long continued it evaporates it, and at laſt reduces the mucilage to the dry and gummy ſtate. Mucus diſſolved in water is not altered; of all the immediate materials it is that which moſt reſiſts ſpontaneous alteration.

16. The weak or diluted acids only diſſolve mucus without alteration. The concentrated ſulphuric acid, by its ſpontaneous action upon this body, decompoſes it, converts it into water without itſelf experiencing any change. It thus ſets its carbon free, and changes part of it into acetous acid. The ſame is the caſe with the muriatic acid, which reduces it to coal in the courſe of time. The oxigenated muriatic acid acidifies it; but it is the nitric acid that acts the moſt powerfully upon it.

17. The nitric acid, ſlightly heated in the proportion of two parts upon one of mucus, till a ſmall quantity of nitrous gas and of carbonic acid is diſengaged, afterwards throws down by the cooling of the whole liquid and diſſolved maſs, a white, ſlightly acid powder, which Scheele has called acid of ſugar of milk, the

ſachlactic

ſachlactic acid of the methodical nomenclature, as it has been eſpecially obtained with the ſugar of milk. As it is not peculiar to the latter ſubſtance, and as it is prepared with all the mucilages, I term it mucous acid.

It is in the form of a white powder, a little granulated, of a ſlightly ſour taſte; it is decompoſed by the action of fire, yields an acid phlegm which cryſtallizes in needles by reſt, a ſmall quantity of oil of a blood-red colour, acrid and cauſtic, carbonic acid gas, and carbonated hidrogen gas: it leaves a great deal of coal; a part appears to ſublime in brown needles or plates of a ſmell analogous to that of the benzoic acid, or perhaps it alſo forms an acid modified differently from what it was at firſt, as the tartareous acid alſo does.

This pulverulent mucous acid has very little ſolubility in water, and that liquid, when boiling, hardly takes up from it more than two or three hundredths of its weight; boiling water does not take up one half more, and nevertheleſs it is depoſited by cooling in brilliant filaments which become white in the air. At the heat of boiling water it decompoſes the carbonates. It forms with pot-aſh a ſalt ſoluble in eight parts of hot water, cryſtallizable by refrigeration. The mucite of ſoda is equally cryſtallizable, and requires only five parts of water to diſſolve it: theſe two ſalts are much more ſoluble by an exceſs of their acid or of their baſes. The mucite of ammonia is little known; it loſes its baſe by the action of heat. We do not yet

know

know the combination of the mucous acid with the other bafes; we only know that the mucites of barites of lime and of magnefia are nearly infoluble. This acid decompofes the nitrate and the muriate of lime, as well as the muriate of barites.

The mucous acid acts but very feebly upon the metals; it appears to form with their oxides falts of little folubility. It precipitates the nitrates of filver, of lead, and of mercury.

The compofition and the proportions of its principles have not yet been determined; we only perceive that it contains a large quantity of carbon; and that in proportion as it is formed by the change of the equilibrium of the component parts of the gums that yield the moft of it, a change effected by the action of the nitric acid, the remaining part of this body is fenfibly lefs carbonated. Citizen Vauquelin and myfelf have found, in our experiments upon this object, that 100 parts of gum yield from 0,14 to 0,26 of mucous acid; that the nitric acid does not change the nature of this acid; that we may caufe it to boil for a long time without its being altered; that it is depofited after cooling in the conftant form of a white powder. None of our experiments have fhown us, as Mr. Hermftaedt has fuppofed, that this acid is an oxalate of lime combined with a fatty matter: all our refearches, on the contrary, have fhown us, that it is a particular acid formed in the firft pe iod of the action of the nitric acid upon the infipid gummy and muci-

 laginous

laginous vegetable ſubſtances. According to this, it is very evident that the name of ſachlactic acid does not ſuit it.

18. With reſpect to the nitric acid, after its firſt re-action upon the mucus has converted it in part into the acid, which I have juſt deſcribed, if we examine the liquor, we find that it contains a ſecond acid, entirely different from the firſt, of a denſe liquid conſiſtence, very ſour, very ſoluble, which Scheele firſt obſerved to be formed by the action of the nitric acid, and which he termed malic acid. This ſecond acid, which holds the middle place, with reſpect to the period of its formation, between the mucous and the oxalic, does not exiſt but when the nitric acid has not been boiled for a long time, or when it has not been employed in a large quantity, or too much concentrated upon the gum. It is not certainly obtained, except after the firſt effervеſcence which I have indicated: it exiſts alſo in the mother water of the oxalic acid. It is eaſily converted into the latter acid, by the ſucceſſive action of the nitric acid. Citizen Vauquelin and myſelf had at firſt believed that this acid was different from the malic: I propoſe to term it the *oxalous* acid, becauſe it precedes the oxalic acid in its formation, and as it appears to me to differ from it only by a little more combuſtible matter, and eſpecially carbon, in its radical. The following are the characteriſtic properties which we have found in it. Its taſte has much analogy with that of lemon juice; it has no colour, but it eaſily becomes red and brown

brown by the progrefs of evaporation. It is eafily decompofed and reduced into coal by the action of the fire. It is very foluble in water, and cannot affume the folid and cryftalline form. It eafily diffolves in alcohol, and does not cryftallize even by the evaporation of this volatile folvent. It precipitates lime-water, and forms with it a calcareous falt, foluble in an excefs of its acid, a property which already diftinguifhes it from the oxalic acid, the combination of which with lime does not diffolve in its own acid. This earthy falt diffolves abundantly in boiling water, forms a folution of a reddifh-brown colour, which precipitates by cooling in the form of ductile, and as it were refinous flakes; thefe flakes, again become brittle by deficcation. With barites it conftitutes a falt that has little folubility, except in its own acid. Thefe falts are decompofed by the fulphuric acid. The oxalic acid itfelf alfo decompofes the calcareous falt defcribed, a proof that the acid indicated is very different from the firft. One of its moft diftinct and moft remarkable properties is, that the nitric acid and the oxigenated muriatic acid fpeedily convert it into oxalic acid. In this converfion nitrous gas and carbonic acid are difengaged: it takes place when we continue to heat nitric acid upon the gum. By this we fee that its formation preceding that of the oxalic acid, and this fucceeding it only by the fixation of a larger proportion of oxigen, it is to the oxalic acid nearly

nearly what the ſulphureous acid is to the ſulphuric, excepting that it loſes alſo a portion of its radical. But by comparing theſe properties with thoſe of the malic acid, we found it to be perfectly identical with that acid.

19. What is moſt ſingular and moſt remarkable in the formation of the mucous and the malic acids, in gum treated by the nitric acid, is their almoſt ſimultaneous creation. In fact, it is very difficult to conceive why the nature of this body is not equally changed throughout the whole of its maſs; why a part becomes mucous acid, and another part malic acid at the ſame time; why it thus divides itſelf into two different ſubſtances, and by what aſtoniſhing mechaniſm, by what complicated attraction theſe two compounds are formed at the ſame time. For the reſt, this character of being divided into two, and ſometimes three products, is found in moſt of the organic materials altered or decompoſed by any re-agent, by whatever cauſe this may be. From 100 parts of gum Arabic we have generally obtained 0,24 of malic acid.

20. When, inſtead of ſtopping the action of the nitric acid after the firſt efferveſcence, or at the period when the malic acid is formed, we continue the application of the heat, and diſengage more nitrous gas and carbonic acid; the laſt mentioned and ſecond acid formed, paſſes into the ſtate of cryſtallizable oxalic acid, decompoſing all the calcareous ſalts, on account of

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its great attraction for lime. As this latter acid exists ready formed in many vegetables, as I shall consider it more particularly in one of the subsequent articles, amongst the immediate materials of vegetables, I only indicate it in this place. I shall only add to this general indication, that after having made it to crystallize, there remains in the last liquor, in the kind of mother-water, which no longer crystallizes, a portion of malic acid above described; but that, by treating the last mentioned liquor again with a new dose of nitric acid, we may change it entirely into oxalic acid.

21. One of the most astonishing facts amongst the discoveries of modern chemistry is, the conversion of gum, or mucilage, into five different acids, according to the manner in which it is treated. In fact, fire develops in it pyromucous acid; the action of the sulphuric and muriatic acids forms acetous acid; that of the nitric acid constantly changes it, in part, into mucous acid, and afterwards, in part, into malic acid, if we do not push its action far, or if we augment it into oxalic acid. Though analogous phenomena present themselves also in several other immediate materials of vegetables, of which I shall speak hereafter, the gum, which presents them the most easily and the most constantly, announces, as we see, in its nature and composition, changes which the pneumatic doctrine alone will be able to determine; for it is evident, from what has hitherto been said, that

that all the caufes of thefe changes have not been exactly difcovered or appreciated.

22. It is to the fame difpofition to change its nature and yield products of very various kinds, that we are to afcribe an effect obferved by Mr. Woulfe, and indicated in the *Journal de Phyfique*, 1788. He obferved, that when gums were diftilled with fixed alkali, much more oil was obtained than when they were heated by themfelves, and that they fwelled confiderably during this operation. This phenomenon depends only upon the attraction which the alkali exercifes upon the pyromucous acid, the manner in which it fixes and retains it, and that in which it determines its decompofition by the action of a violent fire. The carbon and the oxigen then unite together, and the hidrogen united with a portion of carbon, forms oil which is difengaged, while alone it yields a large quantity of water, and fcarce any oil: in the fame manner the acetous acid, diftilled alone, is entirely volatilized, but yields oil when it is heated in union with the alkalis.

23. There is no well-determined action between mucus and the falts. It is eafy to imagine that when it is ftrongly heated with the fulphates, its hidrogen and its carbon muft decompofe thefe falts, and convert them into fulphurets; that the nitrates muft alfo burn it, deftroy it completely, and prefent, after this combuftion, only its moft fixed parts; that thus the nitrate of pot-afh may be employed in order to afcertain

aſcertain the quantity of earth and the fixed ſalts contained in this matter. The ſuper-oxigenated muriate produces this effect in a ſtill more marked manner; it inflames the mucus, and burns it by mere preſſure. A mixture of two parts of this ſalt and one part of gum, in the ſtate of fine powder, detonates by percuſſion, and produces as much noiſe and even more than that of the ſimple combuſtible bodies. There is reaſon to believe that this decompoſition may hereafter ſerve to determine the proportion of the firſt component principles of mucus, as well thoſe of the other immediate materials of vegetables.

24. The metallic oxides moſt charged with oxigen, and adhering leaſt to this principle, may likewiſe ſerve to decompoſe mucus by burning it, like thoſe of ſilver and mercury; this action has not been ſufficiently examined, nor has by any means all the advantage been derived from them which they may afford for this kind of analyſis. The ſame is the caſe with the metallic ſolutions; it has been remarked that they produce a precipitate in the ſolutions of gums; that this flaky and viſcous precipitate carries with it the oxides, and becomes coloured with different tinges, according to the nature of theſe; that in general theſe oxides approach to the metallic ſtate. But it has not yet been determined, with exactneſs, what takes place in theſe precipitations, what kind of attraction the mucus experiences, whether it is changed at the ſame time

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as it is precipitated; or whether the change, fuppofing it to take place, does not happen only a more or lefs long time after the precipitation.

25 From all the chemical phenomena which mucus prefents with the different agents of which I have juft given an account, and efpecially from the comparifon of the action of fire, and of the acids, it muft be concluded that this body is a kind of oxide of hidrogen and carbon, in a ftate of triple combination, fufficiently folid not to be deftroyed but by a violent action, which remains a long time in a ftate of equilibrium, and which is one of the firft formed by vegetation, which cofts the leaft, as it were to the vegetable organization, and is confequently found in moft of the organs of plants. Citizen Vauquelin and myfelf have found, in our inveftigations of the vegetable fubftances, that 100 parts of gum contain 23,08 of carbon, 11,54 of hidrogen, and 65,38 of oxigen.

E. *Species or Varieties of Mucus.*

26. Three fpecies of gum employed in different ufes are efpecially diftinguifhed, the gum of the country, gum Arabic, and gum tragacanth.

A. The gum of the country flows from the apricot, the plum, the cherry, the peach, the almond-tree, &c. and in general from all the ftone-fruit trees. It is white, yellow, or reddifh;

diſh; and when it is well choſen it may be uſed in place of gum Arabic, over which it has the advantage of being cheaper. I have collected upon the bark of the elm a juice of an orange or red colour, in concrete round tears, of an inſipid taſte, ſoluble in water, and forming a viſcous ſolution; it is a gummy matter, which is not ſufficiently abundant to be collected with advantage.

B. The gum Arabic flows from the acacia, the ſame which forms the extractive juice inſpiſſated by the fire; this tree, termed *mimoſa nilotica*, is very abundant in Egypt, in Arabia, upon the banks of the Nile, and in a great number of places in Africa in general. The gum hangs to the tree in maſſes roundiſh, irregular, tranſparent, white, yellow, or reddiſh, frequently furrowed, ſometimes twiſted. The fineſt is the moſt colourleſs and limpid: and is uſed as food by the inhabitants of the country. It is ſometimes called in commerce *Gum of Senegal*: the tears are ſeparated according to their beauty and their purity, in order to diſtinguiſh the different qualities.

C. Gum tragacanth is eſpecially obtained from the ſhrub ſo abundant in Crete, termed *adragant*, *aſtragalus tragacantha* of Linnæus It differs from the two preceding in its form; it is in ribbands, or in plates, or in blades contorted, ſtriated, canulated; of an opaque white colour: it is alſo found in ſmall tears of the ſame colour. Its ſolution is much more difficult

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and more viſcid than that of the gum Arabic, it always contains mucilaginous filaments, or flakes; it is employed as more pure and more uſeful than the latter.

27. Amongſt the numerous plants which contain the mucous juce, either in a gluey or pulverent ſtate, the roots of the mallow, and the bulbs of the lilly, the ſeed of flax, of the quince, are chiefly choſen for extracting the mucilages in common uſe; they are put to macerate in hot water, and thus are formed viſcous, gluey liquids, which ſupply the place of the gums properly ſo called, and which may even be brought to the gummy ſtate by deſiccation. Every country has beſides ſuch a great number of plants which may furniſh mucilages by their maceration in water, that it would be difficult, and uſeleſs alſo, here to preſent their enumeration.

F. *Uses.*

28. Mucus forms in general one of the vegetable materials which nature has beſt diſpoſed to ſerve as nutriment to animals. I have obſerved, that the Africans live upon the gum of the acacia. I ſhall only obſerve, that none but ſtrong and vigorous ſtomachs can eaſily digeſt this inſipid and viſcid juice, and convert it with facility into chyle. An European, who travels in countries where gum is produced, ought not to make uſe of it without ſome kind of ſeaſon-

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ing, and much precaution: for the ſame reaſon the food beſt appropriated to man, amongſt the vegetable matters, is a mixture or a combination of mucous juice and ſugar.

29. In the art of healing, all the gums and all the mucilages are employed with great ſucceſs as emollients, relaxing, ſtrengthening, for quieting irritation, inflammatory heat, and pain; their chief uſe is in topical or external applications to painful inflamed tumors, which ſhow ſigns of commencing reſolution or ſuppuration. This is the reaſon why the mucilages of lint-ſeed, quince-ſeed, mallows, the lily-root, are made to enter into the mixtures of cataplaſms, that are termed ſedative, reſolvent, or emollient.

30. In the arts much uſe is made of gums or mucilages, to give conſiſtence to ſlight piece-goods, and to the colours which are applied over them, and ſometimes to glue or cauſe the ſurfaces of theſe bodies to adhere together. Paper and cloths are ſized by the ſolution of gums. They are employed in order to give body and gloſs to felts, ribbands, and taffetas. Stuffs dipped in gum-water aſſume a tranſient gloſs, and luſtre, which is very quickly deſtroyed by the contact of water. It is alſo made the baſe of the blacking for ſhoes and boots. Gum enters into the fabrication of ink. In a word, the gums and mucilages are very uſeful in domeſtic and manufacturing economy.

Article VI.

Of the third of the immediate Materials of Vegetables, the Saccharine Mucous Substance, or Sugar.

A. Seat.

1. THOUGH ſome chemiſts have nearly confounded mucilage and ſugar with each other, and though the latter ſubſtance has been called pretty generally *ſaccharine mucous matter*; though in fact the ſaccharine has great relation with the mucous matter, it is no leſs certain that there exiſts between theſe two ſubſtances certain differences ſo eſſential that it is impoſſible to confound them, and that render it neceſſary to treat of them ſeparately. Sugar, or the ſaccharine matter exiſts in abundance in vegetables. It may even be ſaid, that there is ſcarcely any part of plants which is wholly deprived of it: but we ought here to ſpeak only of thoſe which contain a ſufficient quantity of it for it to be very perceptible by its taſte, for it to be impoſſible to doubt of its preſence, and for this part to be frequently even employed inſtead of ſugar, or ſugar to be extracted from it more or leſs pure.

2. This

2. This ſubſtance is found very frequently in roots. Beſides the well-known ſaccharine nature of liquorice, ſugar exiſts alſo in ſufficient abundance in carrots, parſnips, turnips, potatoes, onions, to be extracted and obtained ſeparately, as was done by Margraff, by ſteeping theſe vegetables in alcohol, which diſſolves the ſugar without affecting the mucilages and the extracts. It is generally known that the ſaccharine ſtate of theſe roots is developed by the action of fire in decoction. It is alſo known that there are ſome of theſe parts which contain it in ſufficient abundance to be fit for uſe as an aliment. Such is that which Sparmann ſo happily diſcovered in the interior of Africa, which ſerved him for food during part of his journey.

3. The ſtems are frequently filled with ſaccharine juice. Beſides the ſap of the birch, and eſpecially that of the maple, from which ſugar is extracted in America, the pith of ſome palm-trees, that of the bamboo, that of various reeds, the ſtalk of maize, and eſpecially that of the *ſaccharum officinale*, contain it more or leſs abundantly. It is the laſt mentioned plant which, having been tranſported from Africa into America, becauſe the moſt abounding in this product, furniſhes all Europe with the ſugar which is conſumed in ſuch large quantities, and has become an article almoſt of the firſt neceſſity to a portion of the inhabitants of this part of the world.

4. There are many vegetables whoſe leaves are ſaccharine, and many of them exſude a thick juice in ſmall drops, which thickens and becomes concrete at their ſurface in the form of ſmall grains or ſaccharine powder. Such is the manna that proceeds from the aſh, the larch, the alhagi. Such is the dew which covers the ſurface of the leaves of the lime, of the elm, and many other trees with a brilliant and ſaccharine varniſh in hot and dry ſeaſons. This excretion is even conſidered as a kind of diſeaſe of the trees. It is certain that the leaves are in general thoſe parts of vegetables which have the leaſt of the ſaccharine taſte; it ſeems even that this juice, when it exiſts in them, is diſplaced out of its natural ſituation, and as it were by an error of place.

5. On the other hand, there is not perhaps a ſingle flower which is entirely deſtitute of ſaccharine juice. A great number poſſeſs even a particular organ, the nectary, in which this juice is accumulated and depoſited under the name of *nectar*. It exiſts there at firſt in thick tranſparent drops: it afterwards becomes thicker, and aſſumes even the granulated and ſolid form. It is this nectar, which is at the ſame time both aromatic and ſaccharine, which the bees collect, and which they convert into honey, a ſubſtance very analogous to ſugar, which the ancients uſed, as the moderns have employed the latter ſubſtance ſince the diſcovery of America. But no flower or leaf contains a ſufficient quan-

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tity of ſugar for it to be extracted with advantage.

6. The fruits are one of the parts of vegetables in which the ſaccharine matter is moſt abundant. The juice which fills them, the pulp which is incloſed in them, or the fleſh, the more or leſs ſolid parenchyma which forms their texture, are ſo ſaccharine, that it muſt have occurred to the minds of many men to attempt to extract ſugar from them; and it cannot be doubted that this art may be eſtabliſhed at ſome future period with ſucceſs in hot countries, if the advantage of the cultivation of the ſugar-cane ſhould be loſt or diminiſhed by any cauſe: it is known that plums, apples, and figs more eſpecially, are ſo charged with it, that by drying theſe fruits in a ſtove, a conſiderable quantity ſeparates from all their points in grains or in powder.

7. The ſeeds, on the contrary, are perhaps thoſe vegetable parts which contain the leaſt of the ſaccharine matter: but moſt of them have the very remarkable property of becoming ſaccharine by germination. This phenomenon, which is very ſenſible, eſpecially in the cereal or the graminaceous ſeeds, gives riſe to many arts, eſpecially that of brewing. The formation itſelf, or this converſion of an inſipid or mucous vegetable ſubſtance into ſaccharine matter, is one of the facts which muſt throw the greateſt light upon the difference or the relation of theſe two ſubſtances, as I ſhall ſoon ſhow: it is analogous

analogous to what happens in a particular ſpecies of fermentation, which I ſhall diſtinguiſh hereafter, and to what takes place in the maturation of fruits, in which we cannot fail to recognize the production of ſugar by an intimate action of the vegetable materials.

8. Notwithſtanding this multiplicity of places in which we meet with the ſaccharine matter in vegetables, it is to be remarked that it is no where pure, that it is mixed or combined with mucus, with acid, with different kinds of fecula, with extracts, with colouring matters; in a word, that it is not with this ſubſtance as with gum or mucus, which frequently exiſts inſulated, ſo that it may eaſily be extracted or obtained in a ſeparate ſtate.

B. *Extraction.*

9. It is on account of this mixture or combination with ſo many different matters, and ſometimes with ſeveral together, that in order to obtain ſugar properly ſo called, and in the form known to every one, it is not ſufficient merely to preſs the vegetables which contain the ſaccharine juice of which it forms part; but it is alſo neceſſary to prepare theſe juices by proceſſes more or leſs tedious and expenſive, to purify them, to ſeparate from them the fecula, the mucus, and the colouring matter. Two vegetable ſubſtances, namely the juice or ſap of two or three ſpecies of maple, and that of the ſugar-

cane

cane cultivated in America, *arundo facchari-fera, faccharum officinale*, are thofe which afford it the moft abundantly, the moft pure, and with the leaft labour; though thefe laborious operations conftitute an art no lefs complicated than important.

10. In Canada, and in fome of the ftates of North America, the fappy juice of the maple is made to run out by feveral holes bored in the tree at different heights. In the fpring, by placing fnow at the foot of the trees at the clofe of the night, the flow of this fweet fap through the orifices made in the maple trees, is increafed by the contraction thus produced. This fap is boiled in proper veffels till it has acquired the requifite confiftence to fuffer the fugar to cryftallize by cooling; and though this art has not yet been well defcribed, which it would be ufeful to multiply and eftablifh in all the countries in which the maple is fo abundant, it is highly probable that the proceffes of which it confifts are fimilar to thofe which are practifed upon the juice of the fugar-cane.

11. In the South American colonies, in the iflands where the fugar-cane is cultivated in great abundance, the ftem, when ripe and fufficiently yellow, is crufhed between cylinders; the juice which runs out is received into an hollow table placed under the cylinders, and termed melaffes; the cane thus exhaufted is employed as fuel. The fyrup which is more or lefs rich in fugar according to the maturity of

of the cane, the ſoil in which it has been reared, and the ſtate of the atmoſphere that has prevailed during its vegetation, is put into kettles in which it is boiled with wood-aſhes and lime. The liquor is carefully ſcummed; when it is ſufficiently condenſed, or in the ſtate of ſyrup, it is boiled with lime and alum; it is afterwards poured into a back or *cooler*; it is ſtirred with a wooden ſpatula; the cruſt which forms at its ſurface is broken; it is diſtributed into ſhallow wooden veſſels in order to accelerate its cooling; it is poured ſtill luke-warm into caſks placed upright over a ciſtern, and perforated at the bottom with ſeveral holes ſtopped with canes. The juice concretes like a ſalt that cryſtallizes; and the liquid portion or ſyrup into the ciſtern. The ſugar obtained by this firſt operation is termed moſcovado; it is yellow, ſoft, and as it were fatty.

12. This moſcovado, or raw ſugar, is purified or refined in the ſame places by the following proceſs: it is boiled into a ſyrup with a little water; this ſyrup is poured hot into cones of baked earth, or moulds perforated at their lower extremity with a hole, which at firſt is kept ſtopped. Each of theſe cones is placed inverted upon an earthen pot which receives the open point, and ſerves to keep it in a vertical poſition; the ſyrup is firſt ſtirred in theſe cones, and afterwards is ſuffered to cool and cryſtallize. After it has been left to ſtand for fifteen or ſixteen hours, the perforated point of the cones is opened, and

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the portion of the fugar that has not become concrete is fuffered to run out in *coarfe fyrup;* the bafe of the concrete fugar-loaves is fcraped; while pulverized fugar is put in, beaten down, and covered with a layer of clay mixed with water: this water filtrating gradually through the particles of the fugar-loaf, feparates from it the foft brown portion, which is more foluble than the well-cryftallized part; this runs out, carrying with it the *fine fyrup.* This operation of claying is feveral times repeated; the whitened loaves are then taken out, they are dried in a ftove for eight or ten days; they are broken, and reduced into large fragments, which are termed *caffonades,* and fent to Europe.

13. This operation, of which I here give only an imperfect fketch, has not yet been brought to its perfection. Hitherto there have been no able chemifts who have had the means of occupying themfelves with this fubject in the iflands; fome have juft began to attend to it, and at periods when it was not in their power to apply the new difcoveries to this work. It is more than probable that a portion of the fugar is burned in the boilers in which the fyrup is boiled, and that the evaporation ought to be performed with lefs fire. What takes place in the boiling is not yet known. Some think that it ferves to feparate a fecula, an extract, and a colouring matter; to this they think that the afhes and lime contribute; others affert, and Bergman was of this opinion, that the active re-agents

re-agents ferve to feparate a portion of acid that exifts ready formed in the cane-juice, or which the fire required for the evaporation has developed in it. Some imagine that it is only a fimple evaporation and the action of the fire, which on the one hand diminifh the quantity of the water, and condenfe the particles of the fugar, and on the other coagulate and feparate the fecula from the colouring matter. All this uncertainty cannot be diffipated, and the operation cannot be known and rectified till men inftructed in the prefent ftate of chemiftry fhall obferve and examine this operation, upon the place itfelf, and in all its details. The analyfis of the cane-juice will be an indifpenfable preliminary of this excellent and ufeful work.

14. In Europe the caffonades are refined by a procefs which refembles the laft boiling of the fugar. This refining confifts in diffolving the caffonade in water charged with lime, and adding to it ox-blood, fize, or white of egg, in order to clarify it. The liquor is boiled, the fire is afterwards flackened, the fcum carefully removed, the fyrup concentrated by a brifk fire, and the rifing checked by throwing a little butter upon the liquid. When the boiling is completed, the fire is extinguifhed; the liquid is poured into earthen moulds, then ftirred and fuffered to cool; the hole of the moulds is opened; the bafe of the fugar-loaves is clayed with wet argil, and this claying is repeated till the water has carried away all the fyrup. and the fugar is

fufficiently

ſufficiently white; the loaves are dried in a ſtove heated to 40° of Reaumur: they are left eight days in this ſtove, and afterwards put in paper faſtened with packthread. According to the nature of the caſſonades which we treat, we obtain refined ſugar, pure, and more or leſs white. The theory of this operation is not more advanced than that of the boiling of ſugar, and the obſervations which I have made upon the latter apply equally to the refining proceſs.

C. *Phyſical Properties.*

18. SUGAR is not only ſolid like a great number of the immediate materials of vegetables; but it is formed of a great number of cryſtalline grains more or leſs brilliant, and is itſelf capable of aſſuming a regular polyhedral form. When it is made to cryſtallize in the ſtate of ſugar-candy, or when it cryſtallizes in liquors which are ſaturated with it, ſuch as the ſyrups, it is obtained in cuneiform octahedrons, imperfect at their two ſummits, each of which is replaced by a rectangle, or in hexahedral priſms terminated by ſummits of two faces. This property, together with its taſte, have cauſed it to be conſidered as a kind of ſaline ſubſtance, and many chemiſts have conſidered it as holding the middle place between mucilages and eſſential ſalts.

16. On account of its ſaccharine and agreeable taſte, it is diſtinguiſhed and reliſhed by many

many animals, and even by the carnivorous; it is ſo peculiar to it, and characterizes it ſo well, that there is only this ſingle ſubſtance amongſt all the products of nature which enjoys it, and it certainly depends upon its kind of combination, and the particular proportion of its principles. Sugar has no kind of odour, though inſects are attracted from a diſtance by its preſence: it is white and tranſparent, or colourleſs.

17. It is one of thoſe natural bodies which poſſeſs the phoſphoric property in the moſt marked manner. When it is rubbed or grated in the dark, it diffuſes luminous ſtreaks extremely brilliant, and which paſs with the rapidity of lightning. It appears that the caloric, expelled from between the particles of this body thus rubbed and evidently compreſſed, is diſengaged with the accelerated motion which gives it the form of light.

18. Every one knows the extreme brittleneſs of ſugar; but it has not yet been ſufficiently noticed that it is capable of varying in a remarkable manner, and that the denſity of this body may have a great number of different ſtates. Sometimes it is very hard, and does not break without difficulty. That which is well cryſtallized and candied has the vitreous fracture; that which has congealed ſpeedily is granulated. We meet with ſpecimens which, in this laſt mentioned ſtate, are very tenacious, and cannot be broken in pieces without difficulty. Other pieces crumble with the greateſt eaſe. The firſt

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owes its ſtrong conſiſtence to a rapid cryſtallization, and a great degree of dryneſs. The degree of ſoftneſs in the ſecond depends upon the water which it retains between its particles, or which it has abſorbed.

D. *Chemical Properties.*

19. VERY ſtriking relations ſubſiſt between the chemical properties of mucus and thoſe of ſugar. But, though theſe analogies are ſo ſtrong and ſo multiplied, that chemiſts would frequently be at a loſs to diſtinguiſh the products of the one from the other, yet there are ſome particular characters, ſome phenomena produced by various re-agents, which eſtabliſh differences ſufficiently remarkable. I ſhall rapidly paſs over the ſimilar properties, which I ſhall merely indicate, and ſhall dwell more particularly upon thoſe which eſtabliſh diſtinctions conſiderably marked between theſe two bodies.

20. Under the action of fire, the habitudes of ſugar are little different from thoſe of mucus; when heated in contact with the air, it is fuſed more quickly, it is more ſoftened, and is coloured and decompoſed more ſpeedily than gum is; it alſo exhales a more agreeable and more odorous vapour, and leaves a more ſpongy and more dilated coal than that of mucus. Every one knows that ſugar, treated in this manner, is fuſed, ſwells, and diffuſes a ſtrong and agreeable ſmell, known by the name of *Caramel.* If we do not urge this

this decompofition by an open fire fo far as to reduce the fugar to a coal, it remains brown, adhefive, deliquefcent, of an acrid pungent tafte, a little empyreumatic, and very acid. When diftilled in a retort carefully and flowly, by means of a well-graduated fire, it affords more water than gum, ftill lefs oil, more pyromucous acid, lefs carbonic acid, and carbonated hidrogen gas; and its coal, which is lefs denfe, lighter, and more eafy to be incinerated, leaves a little more pot-afh and lime in its refidue. Thefe phenomena indicate a larger quantity of oxigen, and in general a proportion fomewhat different between its primitive principles. This is alfo the true caufe of all the different gradations that will be defcribed in its properties.

21. Sugar is no lefs unalterable by the air than the gums; it is only capable of abforbing a little humidity from it, by an hygrometric effect; it exactly follows all the ftates of the atmofphere when expofed to it. Accordingly, in order to preferve it, care muft be taken to keep it in a warm and dry place, defended againft the viciffitudes of the weather. It diffolves in water, with which it forms, when well faturated with it, a ropy, vifcous liquor, unalterable when pure, and called *fyrup*. The folution, evaporated flowly and fpontaneoufly by the contact of hot and dry air, cryftallizes; and in this manner it is that fugar-candy is made. If the fyrup at the fame time contains fome other matter in folution,

tion, it paſſes into the vinous fermentation, and forms alcohol, of which I ſhall ſpeak in detail in the order of facts in which I ſhall treat of the ſpontaneous alterations of vegetables. Hot and eſpecially boiling water takes up more ſugar in ſolution than cold water, and forms a liquid more denſe and more tenacious than ſyrup. As this kind of ſolution or ſoftening by means of heat may have ſeveral different degrees of denſity, and become more or leſs ſtrongly ſolid or concrete by cooling, great advantages are derived from this very diverſity of its properties in the art of the confectioner; and theſe different ſtates of ſolution, more or leſs denſe and concreſcible, conſtitute the different degrees of the boiling of ſugar, uſed in froſting of confectionary, or comfits, &c.

22. Though there are certain analogies between the manner in which the powerful acids act upon mucus and upon ſugar, they do not extend as far as chemical authors have carried them, but there exiſt between them very remarkable differences. The concentrated ſulphuric acid reduces it to a coal, converts it in part into water as it does gum; but the nitric acid never converts it into mucous or ſacchlactic acid, as it does gum; the ſugar paſſes at once and immediately (under the ſame circumſtances in which gum forms pulverulent and inſoluble mucous acid) into the ſtate of malic acid, and afterwards quickly into that of oxalic acid, by the continued action of the nitric acid. It is alſo

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of all the vegetable ſubſtances that which yields this laſt cryſtallizable acid the moſt eaſily. But it always furniſhes a portion of malic acid at the ſame time, and there always remains a more or leſs abundant portion of the latter in the mother water of the ſaccharine oxalic acid, or that obtained from ſugar, when this mother-water can no longer furniſh cryſtals. This very remarkable difference, this property of not affording inſoluble mucous acid, and of paſſing immediately and at firſt into the ſtate of malic acid, and afterwards very quickly into the ſtate of oxalic acid, has appeared to Citizen Vauquelin and myſelf to depend upon the more oxigenated nature of ſugar than of gum. It is too much ſurcharged with this principle; it is too near to the general ſtate of acid, to be able to form the highly carbonated and very inſoluble mucous acid, to be able to paſs through this firſt degree of inferior acidification. Accordingly, as ſoon as the nitric acid acts upon it, and changes the order of its compoſition, it is not divided into the two firſt acids, the mucous and the malic, but into the two following, the malic and the oxalic. The leſs the acid of nitre has acted, the more the proportion of malic acid exceeds that of the oxalic, though there is always a little of this formed from the commencement of the action of the nitric acid. We here ſee the diviſion of the ſugar into new bodies, a diviſion which invariably characterizes the vegetable ſubſtances.

23. Sugar comports itſelf nearly in the ſame

manner

manner as gum with the alkalis, which cauſe more oil to be obtained from it by diſtillation; and alſo with the nitrate of pot-aſh, which burns its hidrogen and carbon, and inſulates the fixed matters; with the ſuper-oxigenated muriate of pot-aſh, which inflames and detonates ſtrongly with it by percuſſion; with the metallic oxides which burn or decompoſe it; and with the ſolutions of the metals, which alſo precipitate it from its ſolution, and alter it.

24. By the aid of all the means which alter and decompoſe ſugar, we may determine the proportions of its primitive principles, the relative quantities of oxigen, of carbon, and of hidrogen which conſtitute it. Lavoiſier, by uſing the vinous fermentation, which it alone is capable of undergoing, and which conſiſts in a ſpontaneous decompoſition, and in the diviſion into two new compounds, which I have already ſo frequently deſcribed in the vegetable ſubſtances, has found that one hundred parts of ſugar contain ſixty-four parts of hidrogen, twenty-eight parts of carbon, and eight parts of oxigen. Though it appears that this analyſis has not yet been able to receive all that degree of preciſion which it would be poſſible to give it at the preſent day, if we ſhould compare the different reſults afforded by the different means of decompoſition, yet this firſt datum of Lavoiſier, which is not far remote from the truth, ſhows that ſugar is an oxide of carbon and hidrogen, a little more oxigenated than gum, and that it

is in this that its difference confifts. It appears, that the converfion of infipid mucus into faccharine matter is effected in vegetables by mere oxigenation, and by a flight change of proportion in the principles. It is not improbable that art will hereafter be able to convert the gums into faccharine matter; and I have already feveral times obferved, that a folution of gum in water, into which oxigenated muriatic acid gas was made to enter, affumed a faccharine tafte, mixed indeed with a ftrong bitternefs. This profpect which is ftill very new, muft lead to many ufeful refearches and refults. It is already acknowledged by fome modern chemifts, that the mucous and feculent vegetable fubftances are frequently converted in the ftomach, by the procefs of digeftion, into faccharine matter; and it is in this manner that Meffrs. Rollo and Cruickfhank believe the diabetes mellitus to be produced.

E. *Species or Varieties of Sugar.*

25. We have already feen that the faccharine matter is never pure and infulated in vegetables, as mucus fo often is; that it is united fometimes with mucilage, fometimes with fecula, or extractive, and one or more colouring matters, and when we wifh to have it pure, we are obliged to employ different means in order to feparate it from thefe foreign bodies; there are, however, fome faccharine fubftances, which are ufed impure

impure, and ſuch as nature preſents them. Hence it reſults, that four principal ſpecies of ſaccharine ſubſtances, more or leſs in uſe for the common purpoſes of life, are to be diſtinguiſhed; namely, ſugar, properly ſo called, the ſugar of the maple, honey, and manna. Though ſome ſaccharine fruits are uſed in ſeveral countries, as ſubſtitutes for one or other of thoſe ſubſtances, they are only to be conſidered as very imperfect mixtures.

A. I have already ſpoken of ſugar, properly ſo called, becauſe it is the pureſt ſaccharine product, that which is the moſt abundant, and the moſt employed in Europe. It has ſerved in ſome meaſure as a repreſentative of the whole genus. It is known that it is derived from the pilth or medullary and utricular juice, of a gigantic ſpecies of the gramineous plants; that it requires much labour to bring it to its cryſtalline and pure ſtate; that it is not yet even well known in what its preparation and its purification conſiſt, which have not yet been brought to the point of perfection, which may be expected from the preſent ſtate of chemiſtry. This ſugar is employed in different ſtates of purity from the muſcovado and the raw ſugar, the different kinds of caſſonade, the common or officinal ſugar in large loaves, the white and very cryſtalline ſugar in ſmall loaves, the double-refined hard ſugar, very cloſe and very brilliant in its texture, and the ſugar-candy. The ſyrup, and molaſſes are equally applied to a great number of uſes, eſpecially after they have been purified and bleached by heating and cauſing them to throw up their ſkum; by filtrating them through woollen cloths, of a cloſe texture, and ſlightly boiling them with pulverized charcoal.

B. The ſugar extracted from the maple, which in part ſupplies the conſumption of the inhabitants of North America, eſpecially in Canada, forms a ſecond ſpecies very nearly approaching to the firſt in its good qualities, when it is well prepared; it is equally beautiful, equally white, and equally well cryſtallized with that of America, or that of the ſugar-cane; but the labour by which it is procured, is ſtill too long and troubleſome for its quantity to have been yet raiſed to the level of the conſumption, even in the parts of the world where the tree which affords it is the moſt abundant; it appears to be moſt pure in the ſap which holds it in ſolution; it is much more diluted, much more extended with water, and in proportion as its ſolution is condenſed and concentrated, it becomes mucous and coloured. The art of extracting it from the ſap of the maple, is yet very far from having been brought to the perfection which it is capable of attaining, when the lights and the inſtruments of modern chemiſtry ſhall have been applied to it. Perhaps this ſap might firſt be graduated or concentrated by congelation, and thus the great labour and expenſe of its evaporation diminiſhed.

niſhed. It would firſt of all be neceſſary carefully to analyze the ſap of the maple.

C. Honey is the only ſaccharine ſubſtance that was employed in antiquity. It has been pretended that the ancients knew, by proceſſes of purification analogous to thoſe that are practiſed for ſugar, to extract from it a ſolid and concrete matter, capable of being preſerved; but there is no hiſtorical monument to prove the truth of this aſſertion, though there is nothing that directly oppoſes the ſucceſs of ſuch a labour. It is, however, much more probable, that the ancients, who carefully diſtinguiſhed the different ſpecies of honey, and who uſed the greateſt induſtry in the keeping of bees, employed different ſpecies, according to the uſes for which they were deſtined, and ſelected for ſome of theſe uſes, a concrete and granulated ſpecies, more or leſs ſimilar to our ſugar, properly ſo called. Honey is nothing more than the nectar, or the ſaccharine and aromatic juice which the bees collect from flowers, and which they carry in their neſts or hives, for their own ſubſiſtence in the cold ſeaſon, and for that of their young. It eſpecially accompanies the female organs of generation in plants, and is found at the baſe of the piſtils of flowers; generally, it even impregnates the ſtyle, which contains it throughout the whole of its continuity, as we perceive by ſucking theſe parts of the flowers. It ſeems to ſerve, to fix, and conduct the fecundating effluvia of the pollen. Honey

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is a combination of faccharine matter, and aromatic or odorous mucilage. The mucus fubftance which it contains gives it vifcofity, a kind of glutinous quality, deliquefcence, and renders it difficult to be purified.

D. Manna is the fourth fpecies of faccharine matter which I diftinguifh in this genus. It is a gummous faccharine juice, coloured by a naufeous extractive matter; its tafte alfo is difagreeable and very different from that of fugar, properly fo called. It iffues fpontaneoufly in fmall drops, which form folid grains, from the leaves of the pine, the fir, the oak, the juniper-tree, the willow, the fig-tree, the maple, and the olive-tree. It is alfo feen in the form and by the name of honey-dew, upon the leaves of the elm, the linden, and the yoke-elm, the upper furface of which it covers with a light and polifhed integument. Lobel and Rondelet have defcribed, by the name of alcomeli, that which is found upon the olive trees, in the vicinity of Montpellier. Tournefort has likewife collected fome upon the trees in the neighbourhood of Aix and Toulon. But the trees which furnifh the moft of this juice, and from which that which is employed in medicine is extracted, are the afh, the larch, and the alhagi.

The afh, which grows in abundance in all the temperate climates, yields, more efpecially, a large quantity of manna, in Sicily and Calabria. Though the manna collects upon the futures of its leaves, a much larger quantity is obtained

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by making incisions into the tree. The saccharine juice runs out through the apertures, and attaches itself as it dries upon the trunk of the trees, from which it is taken off. When straws or small sticks are placed in the incisions, the manna is formed, by incrusting itself upon them, a kind of stalactites, which are termed *manna in tears*: this is the finest and the purest kind. The fragments which are collected upon the tree itself, and which are irregular, less pure than the first species, form the manna in sorts; as to the pieces which fall on the ground, and which are mixed with much filth, they are termed *fat manna* (*manne grasse*), because they consist of impure tears, glued to each other by a brown, viscous, and as it were fatty juice. The ash sometimes yields manna in our southern departments. Citizen Chaptal has seen some which had been collected at Aniane, about two myriameters distance from Montpelier.

The larch, which grows in abundance in the vicinity of Briançon, affords, during the summer, a kind of manna in small grains, which the inhabitants collect upon the sutures of the leaves of this tree, and put into pots, which they keep in cool situations. This kind of manna becomes very yellow, diffuses a disagreeable smell, and has a much more nauseous taste than the manna of the ash.

With respect to that of the Alhagi, it flows from a shrub, a species of genista or broom which grows in Persia, and respecting which Tourne-

for

fort has given interefting details. It is in the form of fmall grains, which the heat of the fun has dried upon the tree. This manna of the Alhagi is fold in the town of Tauris, by the name of *tereniabin.* It is fcarcely known or employed in Europe.

Manna boiled in a little water, clarified with the white of egg, and fufficiently condenfed, affords real cryftals of fugar.

26. It is now afferted, according to the experiments of Mr. Achard, of Berlin, that folid and cryftallized fugar may be extracted from the white beet-root, with red veins; that this fpecies of fugar may be fubftituted in the place of that of the fugar-cane cultivated in America and Africa, and that it may be afforded at a much lower price. The experiments which are repeating in France upon this fubject, will foon inform us what we have to think of this application of this already ancient difcovery of Margraff.

F. *Uses.*

57. THE faccharine fubftance is an aliment much fought after by a great number of animals, and efpecially by infects. We fee moft of thefe, and efpecially the infects with trunks, affembling about the faccharine juices, attracted even by fragments of folid fugar that have no fmell, and eagerly feizing upon it. It is well known how many infects inhabit flowers,

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and derive their nouriſhment from their nectaries. Man alſo finds in it a part of his ſubſiſtence; numerous facts, and eſpecially what happens in the ſugar colonies, prove that this ſubſtance may ſerve him in the place of food. However, amongſt moſt cultivated nations, it is uſed merely as a condiment, but as ſuch its form is extremely varied, and it is employed for very numerous uſes. It ſerves to preſerve a multitude of ſubſtances, which without it, would be more or leſs alterable, as is proved by the art of the confectioner. It ſoftens the acrimony, improves the taſte, and diſguiſes the inſipidity of many vegetable ſubſtances or foods. Nature herſelf has pointed out its uſe to man, by preſenting it to him in a great number of alimentary ſubſtances formed by the plants, and by uniting it with the inſipid mucilage, the taſteleſs fecula, the pungent acid, the ambroſiacal aroma, &c.

28. Sugar is alſo one of the medicinal ſubſtances moſt in uſe, one of the ſubſtances that are the moſt frequently and the moſt abundantly adminiſtered to the ſick. It is particularly ranked amongſt the emollients, and the ſlight bracers, or even the analeptics, the relaxing, or rather the laxative medicines, and the antiſeptics. It ſerves to ſweeten all medical draughts; and when we calculate the quantity which the ſick generally take of it, we find, that it is ſufficient to ſuſtain, to nouriſh, and to ſupport, ſometimes more even than is neceſſary, the ſtrength re-

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quiſite for the cure of their diſorders. If it be ever ſo little combined with foreign ſubſtances, eſpecially thoſe that have a more or leſs diſagreeable or nauſeous taſte, it becomes purgative, as we ſee in the different kinds of honey, of manna, and in a great number of the laxative fruits. Its antiſeptic and preſervative property ſhows itſelf even when we cover the fleſh of animals, fruits, &c. with a more or leſs thick layer of this ſubſtance in powder. Its agglutinating, and as it were, aſtringent quality, renders it very fit for curing wounds, or cuts, for ſtopping ſlight hemorrhages, by cloſing the lips of a recent wound, and even diminiſhing to a certain degree the bad condition and putreſcency of old ulcers, &c.

29. Sugar is alſo employed in the arts for a great number of uſes, for giving brilliancy to varniſhes, to ink, to paintings, to ſome ſlight ſurfaces; for imparting an agreeable taſte to the mouth-glue; for making ſticking-plaſter; it is the baſe, or the recipient, of a great number of pharmaceutical preparations, &c.

Article VII.

Of the fourth of the immediate Materials of Vegetables, or the Vegetable Acids.

Section I.

Of these Acids in general, of their nature, their Enumeration, and their Classification.

1. THOUGH we may in general consider, as a single one of the immediate materials of vegetables, that acid, which is so abundantly contained in them; though we may be allowed to believe that this substance, which is so well characterized and so easily known, is, wherever it is met with in plants of their products, one and the same matter differently modified, and possessing some varied distinctive properties according to some slight shade in its composition, which is always the same, always identical,—it is nevertheless difficult to avoid considering as real species those among the vegetable acids that present the greatest differences from one another, whether in the properties which all men distinguish in them, or in the uses more or less remote from each other to which they apply them, according to the very dissimilar qualities which they have observed.

2. It will never be poffible to confound the very agreeable acid juice of the lemon, of apples, or of vinegar, with the aftringent tartnefs of nut-galls, and the burning acrimony of the acid extracted from Benzoin. It is true that modern chemiftry has been able to approximate, by its learned fpeculations, and almoft to confound by its ingenious experiments, the juice of apples with the acid of forrel, the acetous acid, &c.; but it has not yet done the fame with all the vegetable acids. Though feveral of them have already been converted by its powerful means into one another, they have not yet all undergone this fpecies of metamorphofis; and though we are permitted to hope, either that all thefe converfions will be effected by future experiments, or that we fhall find out the true caufes of the failure of thefe tranfmutations; it is no lefs certain, that in the prefent ftate of our knowledge it is neceffary carefully to diftinguifh the different acids which the vegetables prefent to us.

3. This part of chemiftry has made immenfe progrefs from the year 1776 to the prefent day. At the former period fcarcely two acids different from each other were diftinguifhed in vegetables, namely, that which was native in them and which was always believed to be a kind of tartar, and that which was the product of fermentation; and neverthelefs, the number of the four plants was found to be immenfe in the firft and moft fuperficial affays of the chemifts;

chemifts; the number of thofe which were obtained in the changes which vegetables were made to undergo by the analytic means to which they were fubjected, appeared equally confiderable. In the prefent ftate of chemiftry we reckon at leaft fifteen fpecies of vegetable acids: the labours of Bergman and Scheele firft opened this brilliant career, which many modern chemifts have followed with a rapid pace.

4. All thefe acids of whatfoever kind, artificial or factitious, are compofed of analogous principles. We conftantly find in them, by exact analyfis, carbon, hidrogen and oxigen; they are all reduced by the oxigenating or burning proceffes into water and carbonic acid. We ought, therefore, to confider them as acids with binary radicals, *hidro-carbonated* or *carbo-hidrogenated*, united with different proportions of oxigen, which differ from the vegetable oxides properly fo called, or from the immediate but not acid materials of vegetables, only by their fuper-abundance of the acidifying principle. In this manner, it will eafily be conceived how the oxides are converted into acids, whether by the action of fire, or by that of the decompofable acids with fimple radicals, or by fermentation. In this manner alfo may be explained the reciprocal converfion of feveral of thefe acids into one another. In order to effect any of thefe converfions, it is fufficient to produce a variation in the proportions of the principles which conftitute the materials

materials or these acids: almost always we extract from them different quantities of hidrogen or of carbon, or both at the same time, and we augment the quantity of oxigen so as to complete their acidification.

5. When we try the plants which we meet with in our walks, with very sensible blue paper, most of them exhibit marks of acidity; but most of them, when treated with more exactness in their juices, are found to contain several acids at the same time; and it is very rare, perhaps even impossible, to find a single acid in any one part of plants, especially in the juices of acid fruits. The same phenomenon is observed when by treating the different vegetable oxides, and especially mucus, the saccharine matter, the fecula, &c. by the different oxigenating or acidifying processes, we convert them into acids: We obtain from them at least two species, frequently three at a time. In this manner I have converted the ligneous substance into four acids, and I have even found five different species in crude and four wines of the vicinity of Paris. It therefore appears that art imitates the processes of nature in the fabrication of the acids; for there are always several of them together, though I must here remark, that the acids simultaneously presented by Nature in a great number of vegetable substances, are frequently of the class of those which art has hitherto been unable to imitate.

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6. In order to know the numerous ſpecies of vegetable acids, for I here comprehend thoſe only which have hidrogen and carbon for their binary radical, and not the acids with ſimple radicals, the ſulphuric, the nitric, the carbonic, which are frequently found combined in the vegetable ſubſtances; it is neceſſary to admit a methodical diviſion between them, a claſſification which enables us to compare them, regularly to explain their diſtinctive characters, their analogies and their differences. With this intention I diſtinguiſh them into ſix genera.

In the firſt I comprehend the native vegetable acids, which exiſt pure and uncombined in plants: this genus includes five ſpecies, viz. the gallic, the benzoic, the ſuccinic, the malic, and the citric.

In the ſecond genus I rank the acids partly ſaturated with pot-aſh, which are termed vegetable acidules, and which include two ſpecies, the oxalic acidule and the tartarous acidule.

The third genus comprehends the acids formed by the fire, or the empyreumatic; of which there are three ſpecies, the pyromucous, the pyrotartarous, and the pyroligneous acids.

To the fourth genus I refer the factitious or artificial acids, which art forms by the action of the oxigenated bodies, or of the powerful acids, upon ſome of the immediate materials of vegetables, and which have not yet been met with in nature. This genus comprehends three ſpecies,

ſpecies, viz. the mucous, the camphoric, and the ſuberic acids.

In the fifth genus I place the artificial acids analogous to the preceding in their factitious oxigen, or produced by art, but which are ſimilar to thoſe which are alſo found ready formed in nature. This fifth genus contains two or three ſpecies, the malic acid, the tartarous acid, concerning which there is ſome doubt relative to its artificial formation, as I ſhall ſhow hereafter, and the oxalic acid.

Finally, I form a ſixth genus of the vegetable acids produced by fermentation; there are as yet only two ſpecies, the acetous and the acetic acids, belonging to this genus, though it is very probable, as I intend to ſhow, that fermentation is capable of producing a greater number of them, which have not yet been examined with ſufficient accuracy to enable us to diſtinguiſh them as particular ſpecies.

SECTION II.

Of the firſt genus of the Vegetable Acids, or of the native and pure Acids.

1. NOTWITHSTANDING the immenſe quantity of ſpontaneouſly acid plants and vegetables which are found in abundance and in all latitudes, chemiſts, in examining plants, have

have hitherto found only five ſufficiently diſtinct ſpecies, differing from each other. It is not, however, to be imagined that the diſcoveries are entirely terminated, or that no hopes are to be entertained of diſcovering hereafter a greater number of them, when the naturally acid vegetables ſhall have been better examined.

2. Though I indicate this firſt genus as containing native and pure acids, I do not ſpeak of entirely inſulated and purified acids, and this purity is to be underſtood only as relative to the acids of the ſecond genus which are partly ſaturated with pot-aſh: in fact, theſe are ſufficiently exempt from pot-aſh and from ſaturation; but they are not completely inſulated and ſeparated from all foreign matter. They are found mixed with mucilage, with acid juices, with light fecula, with colouring matter; and it is neceſſary to employ different means in order to obtain them in the ſtate of purity proper for examining their properties and their characters.

3. Of the five ſpecies of acids comprehended in this genus, three, the gallic, the benzoic and the ſuccinic may be obtained in a cryſtalline form by ſublimation; a fourth aſſumes a very regular cryſtalline form by the evaporation of its ſolution, namely, the citric acid; the fifth cannot acquire this cryſtallization, but always remains in a magma; this is the malic acid. It is, therefore evident, that if we knew only

this property we ſhould be able eaſily to diſtinguiſh them from one another; but their exact hiſtory will furniſh many other characters of diſtinction between them.

Species I.

Gallic Acid.

A. *Hiſtory, Seat, Extraction, Purification.*

1. THE name of gallic acid is applied to that which is extracted from the nut-gall more abundantly than from any other vegetable ſubſtance, though it is alſo contained in the wood and the bark of the oak, of the aſh, the willow, in Peruvian-bark, the Simarouba, the pomgranate, ſumac, the root of tormentilla and biſtort, the cone of the cypreſs, the ſhell of the walnut, the ſtalk of the Iris of the Marſhes, &c. Chemiſts were acquainted with the property which all theſe ſubſtances poſſeſs of precipitating the ferruginous ſalts in the black ſtate, and they attributed it to what they termed their aſtringent property. Macquer, Lewis, Cartheuſer and Gioanetti inveſtigated by ſome experiments, though without adequate ſucceſs, the mode of the operation of theſe ſubſtances upon the ſolutions of iron. Monnet eſpecially announced that the vegetable aſtringents acted immediately upon metallic iron, and coloured it

it black. Gioanetti discovered that the precipitate of ink was not attractable by the loadstone, and that the iron does not exist in it in the metallic state, as had till then been generally believed.

2. Though these facts ought to have led to the conclusion that the principle in the vegetable astringent substances which precipitated iron in the black form was an acid, the academicians of Dijon were the first who adopted this opinion, in 1772. They showed that the products distilled from the nut-gall blackened the solution of sulphate of iron; that this excrescence yielded with cold water an extract amounting to a twelfth of its weight, that its infusion reddened turnsole and blue paper; that the same principle that precipitated iron in the black state was soluble in the oils, alcohol and ether; that the other acids also dissolved without altering it; that its solution in water precipitated the sulphur of the alkaline sulphurets; that it decomposed the metallic solutions, and coloured their oxides by uniting with them; that it dissolved iron immediately, and reduced silver and gold, after having separated them from their solvents.

3. These approximated details afforded as yet only a general proof of the acid nature of the principle of the nut-gall whereby iron was precipitated in the black state; but they did not furnish the means of extracting and obtaining this acid separately, and ascertaining its cha-

characteristic properties. It is to Scheele that we owe the discovery of this acid, by the process which he published in 1780 for extracting it pure and crystallized. He poured upon one part of gall-nuts bruised or reduced to a coarse powder, six parts of very pure water; he left them to macerate for fifteen days at a temperature between 15 and 20 degrees; he filtrated and placed the liquid in a large vessel of glass or of earth in order to expose it to the air and let it slowly evaporate. A blackness, and a thick, and as it were glutinous, pellicle were formed; very abundant mucous flakes were separated; the solution had no longer a very astringent, but a more sensibly acid taste. After two or three months exposure to the air, Scheele observed upon the sides of the vessel in which the liquor was contained, a brown stratum adhering to the vessel and covered with granulated crystals, brilliant, of a yellowish grey colour: he also found a large quantity of these crystals under the thick pellicle with which the liquid was covered. He then decanted the latter; he poured upon the deposit, the pellicle, and the crystalline crust, alcohol which he heated; this solvent took up all the crystallized acid without affecting the mucilage: he evaporated the alcoholic solution, and thus obtained the pure gallic acid in small crystals as it were granulated, brilliant, and of a slightly yellowish colour. It is by this process that the acid of which I speak was prepared after Scheele, till

3 another

another manipulation came to be known, which ſeems to deſerve the preference over it.

4. Citizen Deyeux gave, ſome years after Scheele, a very good Memoir on the Analyſis of the Gall-Nut. He particularly diſcovered, that by heating this excreſcence of the oak pounded, ſlowly and cautiouſly, in a pretty broad and high glaſs retort, it ſublimes a conſiderable quantity of cryſtals, lamellated, brilliant, ſilvery, conſiderably large, and which poſſeſs all the properties of the ſame gallic acid. He indicates this proceſs for preparing this acid; but I ſhall obſerve that this means, which is much more expeditious than that of Scheele, ſucceeds only when the operation is conducted with much caution. It is neceſſary to apply the fire moderately, to take great care not to puſh its action ſo far as to diſengage the oil, for this carries away and inſtantaneouſly diſſolves all the cryſtals that have been ſublimed previous to its appearance. With the aid of theſe precautions, though the fire conſtantly deſtroys a portion of the gallic acid, we always obtain a pretty conſiderable quantity of it, which is very pure, very white, very well cryſtallized, and in this ſtate undergoes no alteration. We do not find in it, after having extracted it by this proceſs, either extractive or colouring matter which alter it in the proceſs given by Scheele.

B. Phyſical

B. *Phyſical Properties.*

5. THE gallic acid, eſpecially as extracted by the ſecond proceſs, is ſolid, cryſtallized in octahedrons with ſcalenous-triangles, or in brilliant plates, of an acid, pungent, and auſtere taſte, but much leſs ſtrong and aſtringent than that of the gall-nut from which it proceeds; which has induced modern chemiſts to believe that this acid is not the ſole cauſe of the aſtringency, as was formerly thought; and, in fact, the acid obtained by ſublimation has much leſs of an aſtringent taſte than that which is extracted by mere maceration, according to the proceſs of Scheele. By the latter preparation, inſtead of having the acid in plates as by ſublimation, we obtain the gallic acid in ſmall octahedrons of a yellowiſh-grey colour.

6. It is very light, and ſuſceptible of being raiſed into vapour by a gentle heat; it condenſes and cryſtallizes as it cools. In its ſtate of vapour, it has an aromatic ſmell, pungent, and conſiderably analogous to that of the benzoic acid. It is quickly fuſed by the fire, and forms, almoſt at the moment of its volatilization, a thick liquid maſs, brown, ſwelled, exhaling an odorous ſmoke, ſo that there is always a certain quantity of it decompoſed. It ſtrongly colours the tincture of Turnſole.

C. *Chemical Properties.*

7. The gallic acid, though volatile at a degree of heat not very confiderable, is at the fame time eafily decompofable, fince every time that we fublime it, a part of it is always decompofed. This decompofition is accompanied with a formation and difengagement of water, of an acid liquid, of carbonic acid gas, of carbonated hidrogen gas, and of fome drops of brown oil: it leaves a coal in confiderable abundance, difficult to be burned and incinerated.

8. This acid is not fenfibly alterable by the air; it requires twenty-four parts of cold water, or at twenty degrees, to diffolve it; it cryftallizes only by a flow and infenfible evaporation: boiling water diffolves a third of its weight. It precipitates from its folution in proportion as it cools, but without a regular form, and difpofed only in fmall grains which do not become white, but remain with their primitive yellow colour. Alcohol diffolves a much larger quantity of it. This liquid when cold takes up one fourth of its weight. When boiling it can hold a quantity of it almoft equal to its own; it is precipitated by cooling. When the folution of the gallic acid in water is kept in clofe veffels, it becomes altered and decompofed, depofits mucous flakes, and the acid is gradually deftroyed.

9. It

9. It is not alterable by the combuftible bodies; charcoal, over which the boiling folution is paffed, whitens it a little. The concentrated fulphuric acid decompofes and carbonates it. The nitric acid changes it into malic and oxalic acids. The oxigenated muriatic acid alfo alters it in a particular manner which has not yet been fufficiently determined though it would be important to afcertain it.

10. The gallic acid combined with barites, ftrontian, lime, and magnefia, forms with thefe bafes falts of little folubility, of a fawn-colour, which an excefs of their feveral bafes caufes to diffolve in water, much more abundantly than they naturally combine with it. Its faline compounds with pot-afh, foda, and ammonia, are not yet fufficiently known, nor have they been fufficiently examined to be well defcribed. We know in general that they have little folubility, and that their generic characters confift only in the precipitation of the metallic folutions into coloured gallates, and efpecially of thofe of iron, into a black or dark-blue powder.

11. That property which moft diftinguifhes the gallic acid from all the other vegetable acids, is the great attraction which it exerts upon the metallic oxides; it is fo ftrong that this acid feparates them from the greater number of the moft powerful acids: the phenomena which the gallic acid, poured into the metallic folutions produces, are extremely various. The more readily the oxides abandon their oxigen, the

the more alterable they are by the gallic acid. Poured into the ſolution of gold, it gives it a greeniſh colour, precipitates from it a brown powder, which is ſpeedily reduced into gold, and covers the ſolution with a pellicle of gold, well reduced, brilliant, and metallic. Silver is ſeparated in a brown precipitate from its nitric ſolution, and a light layer of this reduced metal ſoon covers the ſurface of the liquor. Mercury is precipitated in an orange-yellow, copper in a brown, biſmuth in a lemon-yellow, iron in a black ſtate. The ſolutions of platina, of zinc, of tin, of cobalt, and of manganeſe, are not precipitated by the gallic acid; and it may be here remarked in general, that theſe are preciſely the metals which retain moſt ſtrongly the oxigen neceſſary for their ſaturation, and which are not variable in their oxidation; whilſt thoſe which are precipitable by this acid, ſtop, in general, at different degrees of oxidation, retain but feebly the laſt portion of oxigen which ſaturates them, and are, in general, ſeparated from their ſolvents only at their maximum of oxidation.

12. This has been particularly aſcertained for the ſolutions of iron. Mr. Prouſt has very well proved that ſuch of theſe ſolutions as only contain iron little oxidated, which are ſcarcely coloured and greeniſh, either yield none, or but very little of a precipitate, little coloured, and violet, or of a deep red; that thoſe, on the contrary, in which the iron is ſurcharged with oxigen, form

form immediately a very black precipitate; that it would be advantageous in the preparation of the black pigment, the black-dye, or ink, to employ the red, or fuper-oxigenated fulphate of iron; that it is for want of employing the latter that we are obliged to agitate the ftuffs in the air after they have been taken out of the bath, in order to make them abforb the oxigen which favours the combination of the iron with the gallic acid; that it is for the fame reafon that ink affumes a fine black colour by its expofure to the air; that this oxigenating and blackening effect may be produced at the very moment when the mixtures are made by adding oxigenated muriatic acid to them. Such is the very fimple theory of the fabrication of dyeing mixtures, and of ink, which depend, as we fee, upon the highly oxidated ftate of the iron, and its ftrong union in this ftate with the gallic acid.

13. The whole account which I have juft given of the properties of the gallic acid, proves that it contains the moft carbon of all the vegetable acids, as is demonftrated by its colour, the facility with which it is blackened by the action of the fire and of the air, its little fpontaneous alterability, the large quantity of coal which it leaves after its folution, that of the carbonic acid which it affords in its decompofitions by fire, and by the nitric acid. We might confider it as a kind of carbonous acid, as Citizen Deyeux had conceived it to be, were we

we permitted to exclude the hidrogen from its compofition. But the prefence of the latter principle, which with the carbon conftitutes its binary radical, and affimilates it to all the vegetable acids, and befides is demonftrated to exift in it by all the phenomena of its decompofition, oppofes the admiffion of this opinion, which otherwife is ingenious, though not fufficiently exact for the prefent ftate of chemical knowledge.

D. *Ufes.*

14. THE gallic acid is much employed in dyeing, and in the preparation of ink; it forms the bafe of all the black dyes, and all the grounds of this caft, fuch as the grey, &c. It is never employed in a pure ftate, but mixed, as it is in the vegetable fubftances which contain it, with the aftringent matter, and efpecially with tanin. This is the reafon why the black colour produced by this acid thus mixed, has a red or purple caft which frequently appears when the black is changed. We may prepare ink much more coloured, much more pure, and lefs alterable with the purified gallic acid, than with the decoction of gall-nuts. This acid is frequently ufed in chemiftry in order to afcertain and determine the prefence, the quantity, and even the ftate of iron in a great number of fubftances in folution.

SPECIES II.

Benzoic Acid.

A. *Hiſtory, Seat, Extraction, Purification.*

1. OUR firſt knowledge of the benzoic acid is due to Blaiſe de Vigenere, who wrote at the beginning of the ſeventeenth century. He was the firſt who aſſerted that by diſtilling benzoin a cryſtallized acid ſalt was obtained in odorant and acrid needles, which have ſince been termed in pharmacy *Flowers of Benzoin*. Some chemiſts conceived it to be a modified mineral acid, till the properties that were found in this acid, plainly ſhowed it to be a vegetable acid different from all other acids of this claſs. Geoffroy announced, in 1738, that it might be extracted by water. Lemery gave a very good proceſs for obtaining it by ſublimation. Scheele laſtly ſhowed how to ſeparate it from benzoin by means of lime. Mr. Lichtenſtein has publiſhed obſervations on the proceſs of Scheele and on ſeveral properties of this acid.

2. Benzoin is not the only vegetable ſubſtance which affords the benzoic acid; the acid even bears this name only becauſe benzoin is the vegetable ſubſtance which is moſt commonly employed in order to obtain it, and which yields it in great abundance. It is alſo obtained from

pure

pure ſtorax, from the ordinary ſtyrax, from the balſam of Peru, and the balſam of Tolu, from liquidambar, from vanilla, and even from cinamon, the diſtilled water of which depoſits it in cryſtallized needles by cooling and repoſe: it alſo exiſts in the urine of children, frequently even in that of adults, and conſtantly in the urine of the quadrupeds that live on herbs and hay, eſpecially in that of the camel, the horſe, and the cow. There is reaſon to believe that a great number of vegetables, and even of graſſes, contain it more or leſs abundantly, and that it is from this food that it paſſes into the urine. Citizen Vauquelin and myſelf have found ſtrong reaſons for ſuſpecting it to exiſt in the *anthoxantum odoratum*, a herb which is known to impart an aromatic quality to hay. We have found this acid combined with pot-aſh and lime in dung hill water, as well as in the urine of the quadrupeds that have been mentioned.

3. In order to obtain it by the moſt common or moſt uſeful proceſs, benzoin, coarſely pulverized, is put into an earthen pot; this veſſel is covered with a cone of paſteboard, paſted upon the ſides of the pot: the apparatus is placed upon a furnace charged with very little fire, and even of hot aſhes. At this heat the benzoic acid ſublimes and attaches itſelf to the ſides of the cone, which is taken off and renewed every two hours: this is continued till the ſublimed acid begins to be coloured by the oil which immediately ſucceeds it by the action of

of the fire. Bucquet fubftituted inftead of this apparatus of Lemery, two fimple earthen pans, the margins of which were ground, which he luted upon one another, in order to obviate the lofs of all that quantity of acid which exhales through the pafteboard fides.

4. In the procefs of Geoffroy, the pulverized benzoin was digefted in hot water, which having been filtrated, yielded, by cooling, needled cryftals; but Scheele has obferved that by this means only a fmall quantity was obtained, on account of the incapacity of the water to penetrate the refinous part of benzoin, efpecially when fufed, and which always fwims upon the liquid. On account of this inconvenience, after feveral trials with different alkaline fubftances, he adopted the following procefs: one part of quick-lime is taken, which is firft diluted with three parts of water: about thirty parts of water are added, which are afterwards mixed gradually, and with a motion capable of properly difpofing the fubftances together, with four parts of benzoin in powder: the whole is then heated over a gentle fire for the fpace of half an hour, conftantly ftirring the mixture; it is then removed from the fire, and left to fubfide for fome hours; the clear fupernatant liquor is decanted; eight parts of water is poured upon the refiduum, it is boiled for half an hour, and mixed with the former lixivium. The liquor is reduced by evaporation to two parts; muriatic acid is poured into it drop by drop, till

a flight

a ſlight exceſs has been produced, which forms a pulverulent precipitate of benzoic acid by decompoſing the benzoate of lime diſſolved in the lixivium; the precipitate is well waſhed upon a filtre; and if we wiſh to obtain it in cryſtals, it is diſſolved in five or ſix times its weight of boiling water; it is filtrated through linen, and the ſolution having been ſuffered to cool, depoſits long compreſſed priſms. In this operation, the benzoic acid, ſeparated from the benzoin by the lime, forms calcareous benzoate, which diſſolves in the lixivium, and which the muriatic acid decompoſes on account of its more powerful attraction for the lime.

5. Though Scheele, when he publiſhed this proceſs, neceſſarily announced that it affords as much acid as ſublimation, which had produced him only from 0,08 to 0,10 of the benzoin; notwithſtanding the aſſertion of Spielman, who had made the quantity amount to a quarter of the weight of this balſam; yet Mr. Lichtenſtein has pretended, in new Obſervations, publiſhed in Germany ſince the Memoirs of Scheele, that this operation does not furniſh as much acid as ſublimation; but there is reaſon to believe, with Scheele himſelf, and with Citizen Guyton, that Mr. Lichtenſtein, as well as Spielman, reckon into the weight of the benzoic acid, extracted by fire, the impure portion of this ſalt, ſoiled by a ſmall quantity of oil, which greatly increaſes the quantity; ſo that the proceſs of Scheele

Scheele is not lefs deferving of the preference over all the other methods defcribed before him.

6. We have confirmed the excellence of this procefs, and, in fome meafure, extended its utility, by propofing to extract the benzoic acid, for chemical and pharmaceutical ufes, from the waters of dung-hills, of ftables and ftalls, by means of the muriatic acid, which decompofes in it the calcareous benzoate, and feparates from it the benzoic acid, as in the procefs of Scheele. This new procefs will enable us to reap fome advantage from a fubftance that has hitherto been intirely neglected and ufelefs, namely, the urine of quadrupeds. Should it be feared that the acid obtained by this method might have a foreign fmell different from that which it ought to have, we may diffolve it in boiling water, filtrate its folution, and fuffer it to cool in order to obtain from it the cryftallized acid. By repeating this operation twice in fucceffion upon the acid extracted from the dung-hill water, or from urine, we fhall almoft intirely deprive it of its fmell, which, however, is not fetid, but only a little different from that of the acid as extracted from the benzoin. The urine of the buffalo is that which affords the moft of this acid.

B. *Phyfical*

B. *Physical Properties.*

7. The pure benzoic acid is in the form of a light powder, sensibly crystallized, or in fine needles, the form of which is very difficult to be determined on account of their minuteness. It is white and brilliant when sufficiently pure: that which has a yellow or brown tinge, is soiled by a certain quantity of volatile oil. It is not a brittle substance, as its solidity and crystallized form seems to indicate; on the contrary, it is ductile, and, as it were, elastic. When we attempt to pound it, it forms a kind of paste or pulp.

8. Its taste is acrid, pungent, acidulous, hot, and very bitter. It reddens the tincture of turnsole, but not the syrup of violets. It has not a strong smell when cold, though the slight aromatic odour which it diffuses may, however, serve to distinguish and characterize it; but it assumes a very powerful one when heated, and especially when it is volatilized. It is very light, and occupies a large volume, especially when in the form of long needles intermingled with each other in every direction.

9. When exposed to a gentle fire, it becomes liquefied, forms a soft, brown, and slightly inflated mass, which cools into a solid crust, presenting at its surface marks of crystallization in divergent rays. By the action of a more violent fire it sublimes and exhales into the air in a white,

acrid,

acrid, irritating ſmoke, which ſtimulates the eyes, and produces a diſcharge of tears; it is alſo very ſpeedily volatilized when placed upon an ignited coal.

D. *Chemical Properties.*

10. The benzoic acid inflames when heated ſtrongly in contact with the air, when approached to an inflamed body, when touched, liquefied with a red-hot iron, or when ſubjected to the electric commotion. If heated alone in a cloſe apparatus, the greater part is ſublimed without alteration; but a portion is decompoſed, yields a little acid phlegm, a greater abundance of oil than any other vegetable acid, and eſpecially a much larger quantity of carbonated hidrogen gas than all other bodies of this nature. It leaves merely a trace of coal in the retort. In order the better to decompoſe it, it is neceſſary to treat it in a diſtilling apparatus after having mixed it with ſand: by this means we oppoſe its volatilization, and cauſe it to undergo a ſtronger and more lively action of the fire; we then obtain from it much more phlegm, oil, gas, and coal. The proportion of its principles has not yet been exactly determined.

11. It is not ſenſibly altered by the air; it has been kept twenty years in an open veſſel without loſing any of its weight. No combuſtible body alters it; by diſtilling it with powdered

dered charcoal, it is rectified or refined, and obtained much whiter and better cryftallized than before. It is but very little foluble in water. According to Meffrs. Wenzel and Lichtenftein, four hundred parts of cold water are required for diffolving one part of this acid, whilft the fame quantity of boiling water can diffolve twenty parts of it, nineteen of which feparate from it by cooling. Bergman affures us, that boiling water can take up a twenty-fourth part of its own weight, whilft at the medium temperature it can fcarcely take up one hundredth. Its hot folution becomes turbid as it cools, and the precipitate thus formed is fo abundant that it cannot be filtrated through paper, the pores of which it ftops up.

12. The powerful acids act upon the benzoic acid in a very different manner from that in which they act upon moft of the other vegetable acids. The concentrated fulphuric acid diffolves it eafily and without motion, according to Bergman, who, however, remarks, that part of the fulphuric acid paffes to the ftate of fulphureous acid. We may afterwards feparate the benzoic acid unaltered from this folution, by adding water to it.

The nitric acid diffolves it in the fame manner, and water likewife feparates it from this folution, without its having undergone any decompofition. Citizen Guyton has found that by diftilling nitric acid upon the concrete benzoic acid, nitrous gas was not difengaged till

 towards

towards the termination of the diftillation, and that the acid was then fublimed without alteration. Mr. Hermftaedt however affures us, that by employing concentrated nitric acid, the benzoic acid became fluid, more fixed than it was naturally, and that it affumes the characters of the oxalic tartarous acid: but this refult ftill requires to be confirmed by further experiment. The action of the muriatic and the oxigenated muriatic acid upon this acid is unknown, as are alfo thofe of all the other acids.

13. The benzoic acid unites pretty eafily with the earthy and alkaline bafes. Hitherto the properties of the benzoates, as well as the particular attractions that fubfift between their principles, have been defcribed but very briefly. M. Lichtenftein afferts, that it prefers the fixed alkalis, and even ammonia, to the aluminous, magnefian and calcareous earths. According to the obfervation of Citizen Guyton, it does not appear that he employed the pure and cauftic alkalis in his experiments. Bergman indicates the attractions of the benzoic acid in a different manner. According to him, lime feparates the alkalis from it, and barites feparates the lime; befides it difengages the acid from the carbonates. Mr. Tromfdorf has communicated, in Crell's Annals, a feries of experiments upon the benzoates, by which he has afcertained fome properties of the earthy or alkaline benzoates. By fubjoining to thefe fome facts which I have collected

collected relative to ſeveral of theſe ſalts, I have preſented the moſt complete account of them that has hitherto been given in the Encyclopedic Dictionary of Chemiſtry, from which I ſhall here borrow the principal reſults.

14. The Benzoate of barites is ſoluble, cryſtallizes very well, remains unalterable in the air, is decompoſed by fire and the powerful acids.

No experiments have yet been made on the benzoate of ſtrontian.

The calcareous benzoate is conſiderably ſoluble in water, much more ſo in hot than in cold water; it cryſtallizes by cooling; it frequently aſſumes the form of dendrites upon the ſides of the veſſels. The ſulphuric, nitric, and muriatic acids decompoſe it; barites takes from it its acid, with which it precipitates. It is found in conſiderable abundance in the urine of the herbivorous mammalia.

The benzoate of magneſia is ſoluble, cryſtallizable, and a little deliqueſcent, more decompoſable than the preceding ſalts.

The benzoate of alumine is conſiderably ſoluble, cryſtallizable in dendrites, deliqueſcent, of a bitter and acerb taſte; it is decompoſed by the action of fire, and even by moſt of the vegetable acids.

The benzoate of zircon is not yet known.

The benzoate of pot-aſh cryſtallizes by cooling into ſmall cloſe needles; the drops of its ſolution, ſpread upon the ſides of the veſſels, form

form on them, by cooling and evaporation, dendrites, or herborizations, which indicate its cryſtallizability. All the acids decompoſe it; the ſolution of barites, and of lime, form a precipitate in its ſolution.

The benzoate of ſoda is alſo very cryſtallizable and ſoluble; it is not deliqueſcent like that of pot-aſh, according to Bergman. But it is decompoſable by the ſame proceſſes; it ſometimes exiſts native in the urine of herbivorous quadrupeds.

The benzoate of ammonia has alſo appeared to me to be very ſoluble and very cryſtallizable. Like thoſe of all the benzoates, its ſolution depoſits, when it moiſtens the ſides of the veſſels, and when it dries upon them, dendrites and herborizations. It is volatile and decompoſable by all the acids and all the baſes.

15. Mr. Tromſdorf has found, in his experiments, that the benzoic acid did not act upon the metals, but that it united with their oxides.

The benzoate of arſenic aſſumes, according to him, the form of minute feathers, is ſoluble in hot water, and cryſtallizes by cooling. Hitherto we know no benzoates of tungſten, of molybdena, of chrome, of titanium, of uranium, of nickel, of tellurium.

The benzoate of biſmuth is formed, like all the other metallic benzoates which Mr. Tromſdorf has begun to examine, by diſſolving its oxide in the liquid acid. It affords white cryſtals in fine needles by evaporation; fire diſengages the acid from its ſolution, as the powerful acids alſo do.

The benzoate of cobalt cryſtallizes in laminæ; it is decompoſable by pot-aſh, as are all the metallic benzoates.

The white oxide of mangaeſe diſſolves well in the liquid benzoic acid. This ſolution yields ſmall ſcaly cryſtals, unalterable in the air, eaſily ſoluble in water, but not in alcohol: the alkalis and the alkaline carbonates decompoſe it.

The benzoic acid eaſily diſſolves the oxide of antimony: the ſalt which it forms is unalterable by the air, decompoſable by fire and by the acids. The benzoic acid does not precipitate the ſolutions of this oxide in the powerful acids.

The oxide of mercury obtained by the alkalis, unites with the benzoic acid, which, when it is pure, does not precipitate the nitrate of mercury. This benzoate is in the form of a white powder, unalterable by the air, inſoluble in water, ſlightly ſoluble in alchohol, decompoſable by the alkalis and the acids, ſublimable with a gentle heat, decompoſable by a ſtrong fire, and by ſulphur.

Neither tin nor its oxide diſſolve in benzoic acid, nor enter into combination with it, according to Mr. Tromſdorf; but by pouring a ſolution of benzoate of pot-aſh into the nitro-muriatic ſolution of tin, we obtain immediately

a prea precipitated benzoate of tin, ſoluble in hot water, decompoſable by fire, and not attacked by alcohol. We may form all the metallic benzoates by the ſame proceſs, and it is even the beſt manner of preparing them.

The benzoate of lead, according to the ſame chemiſt, affords cryſtals of a ſhining white colour, ſoluble in water and in alcohol, which the ſulphuric and muriatic acids decompoſe; which are unalterable by the air, and from which fire diſengages the benzoic acid.

The oxide of iron unites eaſily with the benzoic acid, and diſſolves in it; it forms yellowiſh cryſtals of a ſweet taſte, capable of drying and even diſappearing in the air, ſoluble in alcohol, precipitable in the black ſtate by the gallic acid, and into the blue by the pruſſiates, loſing their acid by the action of fire, decompoſable by the pure alkalis which take away the acid, and by the acids which ſeparate it from its baſe.

The oxide of copper, precipitated from its nitrate by the carbonate of ſoda, combines well with the benzoic acid; it forms with this acid ſmall cryſtals of a deep green colour, ſoluble with difficulty in water, and not at all in alcohol, the acid of which is ſublimed by the action of fire, and ſeparated by the other acids, and which the alkalis decompoſe.

The benzoic acid decompoſes the nitrate of ſilver; it unites well with the oxide precipitated from the nitrate of this metal by the car-

bonate

bonate of foda. The benzoate of filver thus formed is foluble in water, and very little fo in alcohol. It is blackened by the contact of light, the acid is volatilized from it by the fire, and the oxide then eafily paffes into the metallic ftate.

The oxide of gold alfo unites, according to Mr. Tromfdorf, with the benzoïc acid; the folution of this benzoate of gold yields irregular cryftals, foluble in water, infoluble in alcohol, unalterable by the air, decompofable by fire, and eafily reducible into brilliant and pure gold during the volatilization of their acid.

The oxide of platina, combined with the benzoic acid, yields fmall yellowifh cryftals, unalterable by the contact of the air, foluble in water with difficulty, and abfolutely infoluble in alcohol, and leaving a yellowifh refiduum after the action of the fire.

16. From all the collective facts relative to the chemical properties of the benzoic acid, it follows that this acid differs from the other vegetable acids in the nature and the proportion of the principles of its radical. Its fmell, its volatility, its combuftibility, its ftrong folubility in alcohol, its little folubility in water, had caufed it formerly to be confidered as an oily acid, and induce modern chemifts to think that it contains in its compofition a large quantity of hidrogen, and that it is by the fuperabundance of this combuftible principle, and by the highly hidrogenated nature of its radical,

dical, that it differs from all the other acidified vegetable compounds. That it is fo little alter-able by the acids, and by the oxigenated bodies in general, is becaufe it is too volatile for it to be practicable to render the action of thefe bodies, which requires to be aided by heat, fufficiently durable, or fufficiently ftrong to effect its decompofition. It eludes it rather by its volatility than by its peculiar nature.

D. *Uses.*

17. If we except its medical adminiftration, which has now become much lefs frequent than formerly, the benzoic acid is of no ufe in the arts. It is prepared in pharmacy, and made to enter into fome medical prefcriptions, in the folid form of electuaries, bolufes, pills, with extracts, fyrups, &c. but it is rarely ad-minifered in the liquid form, on account of its acid and burning tafte.

18. It is extracted and purified in chemiftry, in order to learn its properties, to fubject it to experiments more or lefs connected, and to exa-mine its combinations. It is, however, one of the acids that are prepared the leaft frequently, that are met with in the leaft abundance in the laboratories of chemiftry, and which are the moft rarely employed in experiments.

Species III.

Succinic Acid.

THE succinic acid, so named, because it is extracted from amber, a bitumen which manifestly has a vegetable origin, belongs really to the vegetable acids: it is a combination of hidrogen, carbon, and oxigen, decomposable in water and carbonic acid, by the action of the fire and the comburant bodies. I here only indicate it, as I shall examine it more in detail in the order of facts relative to the alterations which vegetables are susceptible of experiencing in the earth. I place it in the method which I adopt for the acids, in the series of the gallic and the benzoic, because, like these it is capable of subliming and of crystallizing by sublimation.

Species IV.

Malic Acid.

A. *History, Seat, Extraction.*

1. THE malic acid bears this name because it has been more especially found by Scheele in the juice

juice of apples. It exiſts alſo in a great number of fruits; it exiſts in ſmall quantity, mixed with much citric acid in the fruits of the *vaccinium oxycoccos*, of the *vitis idæa*, of the *prunus padus*, of the *ſolanum dulcamara*, of the *cynoſbatos*. It is found in abundance, and with very little citric acid, in the barberry, the elder, the plum; nearly equal parts of both acids are extracted from the currant, the blackberry, the cratægus aria, the cherry, the raſpberry, the ſtrawberry. Theſe are the reſults of the fine experiments of the Swediſh chemiſt on the juices of all theſe fruits.

2. Notwithſtanding this multiplicity of vegetable matters that contain the malic acid, it is the moſt abundant, and moſt pure, in the apple, and this is the fruit from which it is the moſt eaſily extracted. The following is the method of proceeding, according to the diſcovery of Scheele, in the extraction and purification of this acid. Sour apples are pounded in a mortar, the juice is preſſed out, it is filtrated through linen, and a ſolution of acetite of lead, or *ſaccharum ſaturni*, is poured into this diſſolved ſalt. The acetous acid unites with the pot-aſh, and remains in ſolution in the liquor, whilſt the acid of apples, combined with the oxide of lead, is precipitated in an inſoluble malate of lead. This precipitate is then well waſhed; and treated with ſulphuric acid diluted with water, ſulphate of lead is formed, which is precipitated, and the ſupernatant liquor

quor contains the malic acid feparate. Care is taken to add a fufficient quantity of fulphuric acid to decompofe the whole of the malate of lead; which is known to have been done by the acid, pure tafte of the fupernatant liquor, free from any admixture of faccharine flavour. Should there be a fmall excefs of fulphuric acid, it is made to difappear by adding a fmall quantity of malate of lead, which this acid decompofes and converts into fulphate of lead.

3. When the malic acid is found mixed with citric acid, as is the cafe in many of the juices of fruits, and efpecially in that of the goofeberry, the following is the method by which Scheele fucceeded in obtaining each of thefe acids feparate. He firft infpiffated this juice to the confiftence of honey; he then poured upon it alcohol, which diffolved the two acids, and left a large quantity of gummy mucilage; he afterwards evaporated this alcohol; he diluted the liquor which remained after this evaporation with two parts of water; he faturated it with chalk or carbonate of lime; he feparated by evaporation the calcareous citrate which is much lefs foluble, and the calcareous malate which remained in it afterwards, by a frefh quantity of alcohol, which did not diffolve the falt, but a faponaceous and faccharine matter which was combined with the malate of lime; he decompofed the malate of lime by the acetite of lead; he afterwards treated the malate of lead that was formed with fulphuric acid, and

thus

thus he obtained the malic acid pure and infulated.

B. *Phyfical Properties.*

4. The malic acid thus prepared is a brownifh-red liquid, of a confiderably pungent and lively acid tafte, without acrimony, but frequently affording a faccharine after-tafte, however well it may have been purified. It reddens the blue vegetable colours well.

5. It never affumes the cryftalline and folid form; it becomes thick and vifcid like a mucilage or fyrup; when it is expofed to dry air, it dries in minute layers, like a brilliant varnifh, and might be employed for fpreading over polifhed furfaces.

C. *Chemical Properties.*

6. This acid is eafily decompofed by fire; it tends to lofe carbon fpeedily; it becomes of a very deep colour, fwells confiderably, exhales a thick and pungent fmoke in the open air, and leaves a very voluminous coal, fimilar to thofe of mucilage and fugar. When it is diftilled in a retort, it yields acid water, much carbonic acid gas, fome carbonated hidrogen gas, and a light fwelled coal. Its empyreumatic acid appears to be the pyromucous acid.

7. It is decompofed gradually and fpontaneoufly in the veffels in which it is contained, it ferments

ferments fenfibly, becoming at firft flightly vinous, depofits mucous filamentous flakes, which at laft are reduced to coal. It is very evident that this decompofition is produced by the intimate re-action of the component principles of this acid. Its mechanifm will be ftill better underftood from the hiftory of fome of the fubfequent acids.

8. All the powerful acids alter it and change its nature; the concentrated fulphuric acid reduces it to coal; the nitric acid converts it into oxalic acid. Scheele had already found that infipid mucous matter, treated by the nitric acid, paffes into the ftate of malic acid, or was converted at the fame time into this acid and into the oxalic. Thus the malic acid is fabricated artificially, and we muft recognize in it a double origin, that of nature and that of art, as in feveral other vegetable acids of which we fhall foon treat.

9. The malic acid forms with barites a cryftallizable and foluble falt; with lime it yields fmall irregular cryftals, little foluble in boiling water, but very foluble in an excefs of malic acid, as well as in vinegar, like the malate of barites itfelf. The malate of lime thus diffolved by its acid, forms, by thickening in the air, a folid, brilliant fubftance analogous to a layer of varnifh. The malate of magnefia is deliquefcent, that of alumine has little folubility. The malates of zircone and of ftrontian are not known. The malates of pot-afh, of foda, and

of

of ammonia appear to be ſuſceptible of attracting the moiſture of the atmoſphere. The comparative attractions which this acid exerts upon the different alkaline and earthy baſes have not been determined, ſo that the laws relative to the decompoſition of theſe ſalts are as yet unknown.

10. The malic acid precipitates the nitrates of mercury, of lead, and of ſilver, and is thence diſtinguiſhed from the citric acid, which does not effect this precipitation in like manner. It alſo decompoſes the ſolution of gold diluted with water, the metal of which it reduces. It diſſolves iron, and forms with it a brown uncryſtallizable liquid; with zinc, which it diſſolves well, it gives a ſalt in regular cryſtals of conſiderable magnitude. Its combinations with other metallic oxides have not yet been ſtudied.

11. It preſents itſelf in all theſe phenomena of combination and of decompoſition, though hitherto little known, as a vegetable acid in which the proportion of carbon is pretty conſiderable.

D. *Uſes.*

12. The malic acid has hitherto been prepared only for chemical uſes, and for the ſeries of experiments that lead to a knowledge of its properties. It might ſerve for a refreſhing beverage,

beverage, or as a condiment, like feveral other vegetable acids.

Species V.

The Citric Acid.

A. *Hiftory, Seat, Extraction.*

1. CHEMISTS formerly compared the acid juice of lemons with the acid of tartar: they endeavoured to concentrate this acid and to purify it, in order to prevent this juice from becoming altered and fpoiled, as ufually happens when it is kept in bottles. In fact, every one knows that this juice, though very acid, and weighing 1060 according to Citizen Guyton, becomes turbid and covered with mould when it is kept in veffels; it depofits mucous flakes, and at laft lofes its acidity; affuming a very difagreeable, putrid, and faint tafte. Some perfons have partly defended it againft this alteration by covering it with oil in the veffels in which they kept it; others thought to effect this purpofe by putting fand into it; and others added to it a mineral acid; but thefe different means either themfelves contribute to alter it, or do not prevent its change. The oil, which was moft preferable, did not, however, prevent the lemon-juice from contracting, after

 fome

fome days, a harfh, oily, and difagreeable tafte.

2. Mr. Georgius publifhed, in the Memoirs of Stockholm for 1774, a better procefs of concentration. This confifted in keeping the lemon-juice for fome time in a cellar, in inverted bottles, in order to feparate from it a part of the mucilage, and afterwards to expofe it to a cold of from 4 to 5 degrees below 0; the aqueous part was thus congealed, taking with it a portion of the mucilage; this was feparated, and the liquid was continued to be expofed to the froft, till the concrete portion had an acid tafte. The juice thus reduced to one eighth of its original volume, is eight times ftronger than before, and it requires the fame quantity of pot-afh to faturate it as the original quantity of the juice required. In this ftate of concentration, it remains unaltered, and may be employed for every domeftic and economical purpofe.

3. It is well known to every one who has extracted and examined the juice of the lemon, that this liquid, when expofed to the air in an open veffel, at a temperature of above 15 degrees, depofits a mucous, whitifh, femi-tranfparent matter, of a gelatinous confiftence. When the juice is decanted from over this depofition, and filtrated, it is much lefs alterable than it was previous to the operation. The uniform fubftance thus feparated is not a fimple vegetable mucilage: I have found that when dried it is not foluble in boiling water; that,

that, if treated by the nitric acid, it yields azotic gas, is converted into malic and oxalic acids, and that it thus has ſome analogy with the glutinous principle. This explains a proceſs followed and deſcribed by Citizen Dubuiſſon Limonadier, at Paris, for the purification and preſervation of lemon-juice. By evaporating it with a gentle heat, continued for a long time, he found that its mucilage became thickened, and ſeparated in the form of a glutinous cruſt and flakes; the acid liquor then becomes concentrated and may be kept for a long time in well-corked bottles; there afterwards ſeparate from it only a few white and ſolid flakes which ſwim upon the ſurface, without the nature of the acid being changed, or its flavor being altered, or loſing any of its ſtrength.

4. Theſe different means, however, were only in ſome meaſure preparatory; they did not yet afford either a method for obtaining the citric acid really inſulated and pure, or an opportunity for examining its properties. Scheele nearly accompliſhed this work by preſenting a proceſs for obtaining the citric acid conſiderably pure; and to him we are at the ſame time indebted for the firſt deſcription of the real diſtinctive characters of this acid, which till this time had been confounded with the tartarous. Stahl indeed knew, at the commencement of the century, that lemon-juice combined with Crabs claws aſſumed the nature of vinegar; ſeveral chemiſts alſo had deſcribed, after him, ſome

 pro-

properties of the combinations of this acid; but thefe were only vague and inaccurate notions before the difcoveries of the Swedifh chemift. The following is the method by which he fucceeded in obtaining the real citric acid, after having tried in vain to purify the lemon-juice with alcohol, which does not feparate the mucilage completely enough to infulate this acid, or to admit its being obtained in cryftals, as may be done when it is fufficiently pure.

5. The lemons are preffed, the juice filtrated or drawn off clear is faturated with carbonate of lime. After the effervefcence which difengages the carbonic acid, a pulverulent infoluble falt is formed, which precipitates to the bottom of the liquid; the fupernatant water retains the mucilage, the extract, and the colouring matter of the juice; the precipitated citrate of lime is wafhed with lukewarm water, till this paffes off colourlefs; it takes up only about as much falt as it would take of fulphate of lime: the falt wafhed with a little water is poured into a matrafs; a quantity of concentrated fulphuric acid requifite for faturating the proportion of chalk that has been employed is added, after having diluted this acid with ten parts of water; it is then boiled for a few minutes, and after cooling, the liquor is filtrated: the fulphate formed by the decompofition of the calcareous citrate remains upon the filtre; the liquor that has been filtrated contains the

the citric acid pure; it is evaporated to the confiftence of a clear fyrup, and put to cryftallize in a cool place: in this manner we obtain the citric acid in fmall needles. According to Scheele, it is neceffary to add a fmall excefs of fulphuric acid, which remains in the mother-water of the cryftallized acid. This excefs produces better effects than an excefs of lime or of citrate of lime, which would prevent the cryftallization of the citric acid.

6. I have propofed long fince to execute this procefs in the large way in our American poffeffions, where lemons are fo abundant, and where a large quantity of them is loft; it would only be requifite to faturate the expreffed juice with chalk, to wafh the precipitated calcareous citrate well till the hot water paffes off infipid and colourlefs, to dry the precipitate well, and to fend it, preffed in barrels, to France, where it might be decompofed by means of diluted fulphuric acid, in order to obtain from it the citric acid pure. This procefs which I have indicated more than ten years ago in my courfe [of lectures] will be very economical and very ufeful; it will give a value to immenfe quantities of lemons that have hitherto been loft, and will furnifh a fubftance which is fo often wanted, which is always fcarce and dear in the North of Europe, and which is fo ufeful for chemical and medical purpofes. Since I have indicated it, I have not had the fatisfaction of feeing it put in practice; but this view will not always

be loſt, and it is to be believed, that when it ſhall have been diffuſed amongſt the American coloniſts, it will preſent them with the means of turning to profit a product which is ſo abundant near their habitations, and which they ſuffer to be loſt in ſuch large quantities.

7. Citizen Dizé, an able practitioner of Pharmacy at Paris, by repeating with care and upon a very large ſcale the proceſs of Scheele for extracting the pure citric acid from the juice of the lemon, in the large pharmaceutical eſtabliſhment at the military School, of which he has the direction, has had an opportunity of making ſome important obſervations on this preparation. He has aſſured himſelf, not only that an exceſs of ſulphuric acid is neceſſary for obtaining this acid pure, but that it ſerves to deſtroy the portion of mucilage which alters it, by determining its decompoſition; he has obſerved that, in order to have the citric acid perfectly pure, it was neceſſary to diſſolve and to cryſtallize it ſeveral times ſucceſſively. He has ſucceeded in obtaining it in the form of very voluminous, and almoſt gigantic cryſtals, perfectly formed, and the figure of which he has been able exactly to determine. He has deſcribed its ſolubility, compared its energy, confirmed the facts announced by Scheele, relative to its action upon the ſolutions of ſome earthy and metallic ſalts, and thus rendered its hiſtory more exact.

8. Laſtly, Citizen Vauquelin has undertaken, at my ſolicitation, a ſeries of experiments

ments upon the faline combinations of the citric acid, and has greatly added by his refearches to the fmall ftock of knowledge that before exifted relative to the properties of this acid; fo that it was now one of the beft known of all the acids which the vegetables prefent.

I ought here to repeat that the citric acid is rarely found alone, but mixed with different proportions of malic acid in the juices of the barberry, the cherry, the ftrawberry, the rafpberry, the fruit of the fervice-tree, the elder, and a multitude of other fruits; that it is eafily feparated from this malic acid on account of the little folubility of the citrate of lime which is precipitated, whilft the malate of the fame bafe remains in folution in the liquor.

B. *Phyfical Properties.*

9. The citric acid, when fufficiently pure, cryftallizes in rhomboidal prifms, the fides of which are inclined towards each other at angles of about 60 or 120 degrees, terminated at both ends by fummits with four faces, which intercept the folid angles; the beautiful cryftals are obtained only by letting large quantities of the folution of the well-purified acid evaporate to the confiftence of a clear fyrup. The fmall quantities upon which Scheele operated did not permit him to have it regular, and it is only fince the operations in the large way of Citizen Dizé

Dizé that the perfect form which I have juſt deſcribed has been known.

10. The citric acid has ſo ſtrong and pungent a taſte in this ſtate of cryſtallization, that when taſted we experience a ſenſation almoſt like that of a cauſtic; it, however, is not ſuch, and when diluted with a little water, its cool, though pungent taſte is agreeable; it is not characterized, or at leaſt but very ſlightly with the ſmell of the lemon. It ſtrongly reddens the blue vegetable colours; it melts very quickly in its water of cryſtallization under the action of the fire.

C. *Chemical Properties.*

11. When the ſolid citric acid is heated upon ignited coals, it ſoon fuſes and runs; it ſwells and exhales an acrid and ſtimulant vapour, which does not reſemble that of fried ſugar or caramel, as that of the malic acid does; treated in the ſame manner it is at laſt reduced into coal, which is not by far ſo abundant or ſo much inflated. Diſtilled in a retort, it is diſengaged in part without decompoſition; it appears to yield a portion of vinegar; afterwards it gives carbonic acid gas, a little carbonated hidrogen gas, and a light coal remains in the retort. In general, it is one of the acids that moſt reſiſt decompoſition by fire.

12. When expoſed to the air, it ſeems to effloreſce in a dry and warm atmoſphere; but it

abſorbs

abſorbs humidity when the air is charged with it, and at laſt loſes its cryſtalline form. It is very ſoluble in water; Citizen Vauquelin has eſtimated that 100 parts of this acid diſſolve in 75 of water at 15 deg.: this ſolution produces ſome degrees of cold. Though it is much leſs alterable than moſt of the other vegetable ſolutions, it is nevertheleſs at laſt decompoſed when kept for a long time in cloſe veſſels; it precipitates mucous flakes; it is probable that it is converted into acetous acid previous to its deſtruction.

13. The citric acid is not altered by any combuſtible body; charcoal alone amongſt theſe bodies appears to be capable of whitening it. The more powerful acids decompoſe it with much more difficulty than they do the other vegetable acids. However, the concentrated ſulphuric acid manifeſtly converts it into acetous acid. The nitric acid, according to Scheele, does not change it into oxalic acid; but Citizen Vauquelin and myſelf have found in our inquiries, that in the courſe of time, by employing a large quantity of it and heating it for a long time, the citric acid is decompoſed by the nitric acid, and converted into a ſmall portion of oxalic acid, and a much larger of acetous acid.

14. The combinations of the citric acid with the earthy and alkaline baſes have been examined with conſiderable care by Citizen Vauquelin.

A. Twelve

A. Twelve parts of citric acid diſſolved in water yielded twenty-four parts of citrate of barites. The firſt portions of the ſolution of barites, poured into that of the citric acid, form a flaky precipitate ſoluble by agitation; the precipitate was not permanent till the period when the whole of the acid was ſaturated: this ſalt, at firſt depoſited in the form of powder, collects itſelf afterwards into ſilky tufts, and a kind of ſilvery buſhes, very brilliant and beautiful. A large quantity of water diſſolves it. This citrate contains equal parts of acid and of baſe.

B. Twenty-four parts of citric acid required eighteen parts of cryſtallized carbonate of lime for their ſaturation. 100 parts of this ſalt contain 37,34 of lime and 62,66 of citric acid. When the citric acid had been ſaturated by the lime, ſmall cryſtals were formed, which precipitated themſelves upon the carbonate of lime, and cover it in ſuch a manner as to oppoſe its ſolution, in order to complete which it is neceſſary to ſtir it from time to time. This is the ſalt which is prepared in order to purify and obtain the citric acid: it is known to be very little ſoluble, and decompoſable by the ſulphuric acid.

C. Thirty-ſix parts of acid diſſolved in the proportion indicated No. 12, a proportion which has been conſtantly employed in the experiments of Citizen Vauquelin, required for their ſaturation 61 parts of cryſtallized carbonate of pot-aſh. Hence it follows that 100 parts of

citrate

citrate of pot-aſh contain 55,55 of acid, and 45,45 of pot-aſh. This ſalt is very ſoluble and does not cryſtallize without difficulty; it is alſo deliqueſcent and decompoſable by barites and lime.

D. 36 parts of acid ſolution abſorbed 42 parts of dry carbonate of ſoda; whence it follows that the citrate of ſoda contains 60,7 of citric acid, and 39,3 of ſoda. This ſalt is very ſoluble; one part requires only 1⅔ of water to diſſolve it. Its taſte is ſaline and faint; it cryſtallizes in priſms of ſix ſides without pyramids; it ſlightly effloreſces in the air without being reduced into powder. It boils, ſwells, and is reduced to coal by the fire. Barites, by decompoſing it, fomrs a precipitate. Lime-water, though it decompoſes it, does not render its ſolution turbid, notwithſtanding the ſparing ſolubility of the calcareous citrate.

E. 36 parts of acid, diſſolved, ſaturated 48 parts of cryſtallized carbonate of ammonia. 100 parts of this ammoniacal citrate contain 62 parts of acid and 38 of ammonia; it is very ſoluble in water; it does not cryſtallize unleſs when its ſolution has been condenſed: the form of theſe cryſtals is an elongated priſm.

F. 36 parts of acid required forty parts of carbonate of magneſia for their ſaturation. One hundred parts of magneſian citrate contain 33,34 of magneſia, and 66,66 of acid. The condenſed ſolution of this ſalt did not cryſtallize, after ſome days, when, by a ſlight agitation,

tation, it affumed the form of a fingle white and opaque mafs, which remained foft, feparating itfelf from the fides of the veffel, and contracting its dimenfions and elevating itfelf in the middle, in the form of a mufhroom nearly twelve centimetres in height.

G. The citrates of ftrontian, of glucine, of alumine, and of zircone, have not yet been examined.

15. Hitherto the action of the citric acid upon the metals has been little ftudied: we have feen that Scheele found that this acid did not precipitate the nitric folutions of the white metals, as the malic acid does. Citizen Vauquelin has ftudied fome of the combinations of the citric acid with thofe combuftible bodies. The following is a fketch of his refearches on this fubject:

A. Fifty parts of zinc being put into a folution of citric acid, an effervefcence was occafioned by the difengagement of hidrogen gas. At the end of twenty-four hours the action was over, and the liquid had depofited upon the fides of the veffel, and at the furface of the plates of zinc, fmall brilliant cryftals infoluble in water. One hundred parts contain nearly equal parts of acid and of oxide of zinc.

B. Iron was attacked in the fame manner as zinc by the liquid citric acid; the effervefcence continued four days; the folution was of a brown colour; by fpontaneous evaporation it depofited fmall cryftals of citrate of iron. By evaporation it it became black like ink, ductile like hot refin, pulverulent, and very black when cold. This falt is very aftringent and very foluble in water. It contains 30,38 of oxide of iron, and 69,62 of citric acid.

C. The citric acid does not attack filver, but it unites with its oxide, with which it forms a falt infoluble in water, of a harfh and very ftrong metallic tafte, which affumes a black colour when expofed to the rays of the fun, is decompofed and yields acetous acid, if concentrated by diftillation, and after this operation, leaves the metallic filver in veget-getation, of a very agreeable appearance at the bottom of the retort, mixed with a little coal. This falt is decompofable by the nitric acid; it contains in an hundred parts thirty-fix of citric acid and fixty-four of oxide of filver.

D. The citric acid does not unite directly with mercury, but it combines very well with its oxide. Red oxide of mercury placed in contact with a concentrated folution of this acid, produces a lively effervefcence, becomes white, and affumes a form of a very folid mafs. By adding water to this folid compound, it becomes white like milk; by heating the liquid, a very fenfibly acetous fmell becomes at laft perceptible. This falt is not perceptibly foluble, though it has a mercurial tafte. The nitric acic decompofes it. Diftilled with a naked fire it yields acetous acid and carbonic acid, without hidrogen gas: the mercury is reduced,

reduced, and there remains a light coal in the retort.

16. By comparing all the properties of thefe different falts, Citizen Vauquelin has drawn from their properties fome important refults for the hiftory of this acid, and for the characters of the genus of the citrates. All the alkaline citrates are precipitated by the folution of barites. The precipitate which they form with the calcareous falts is foluble in lefs than five hundred parts of water. All thefe citrates are decompofed by the powerful acids, which do not form in them any precipitate as they do in the oxalites and the tartrites. The oxalic and tartarous acids decompofe them, and form in their folutions cryftallized or infoluble precipitates. All thefe yield either traces of acetous acid, or a product of this nature by diftillation; this character exifts particularly in the metallic citrates. The citrates placed upon burning coals are fufed, fwell, exhale an odour of empyreumatic, or burned acetous acid, and leave a light coal. All, when diffolved in water, and left to themfelves for a longer or fhorter time, are decompofed, depofit mucous flakes which become black, and leave their bafes infulated in combination with carbonic acid, one of the products of this decompofition: before the complete decompofition, they feem to pafs into the ftate of acetites.

17. The attractions of the citric acid for the bafes have been afcertained by the fame chemift in

in the following order; barites, lime, pot-aſh, ſoda, ſtrontian, magneſia, ammonia, and alumine; its attractions for zircone, and glucine are not yet known. Neither have its attractions for the metallic oxides been determined, nor in what order each of theſe burned bodies adhere to this acid.

D. *Uſes.*

18. The citric acid is very much uſed in the ſtate of lemon-juice. It is a condiment which is preferred to vinegar on account of the ſlight aroma which accompanies it. When purified it may ſupply the place of the juice of the fruit in all economical uſes; but it ſhould be employed in very ſmall quantities. As it may be kept without alteration in its cryſtalline form, it would be very advantageous to prepare the citrate of lime in our colonies, and import it into Europe, where its acid might be extracted by means of weak ſulphuric acid. Two grammes of this concrete acid, diſſolved in a kilogramme of water, with a ſufficient quantity of ſugar and *oleo-ſaccharum* made with lemon-peel, afford a very agreeable lemonade.

SECTION III.

Second Genus of the Vegetable Acids, or Acidules.

1. THE term of acidules is applied in the methodical nomenclature to the natural combinations of the acids, with a portion of pot-ash, which remarkably changes their properties.

There are only two of these acids that have hitherto been found in this state of semi-saturation. The other vegetable acids do not affect this state of acidules, as they have not the property of being able thus to unite in part with pot-ash, and to remain in a state of semi-saturation with this species of alkali; the cause of the existence of this property in only two, and its absence in all the others, is yet entirely unknown; it depends, undoubtedly, upon the intimate nature of these bodies, and their order of primitive composition.

2. At the same time that only two acids have hitherto been found to possess the character of acidulity, it is to be observed, that these same acids are not found, or are found but very rarely in the pure state, and without being semi-saturated with pot-ash; which is owing, on the one hand, to the great tendency which these acids

acids have to unite with pot-aſh, or the very ſtrong attraction for it, which they poſſeſs; and on the other, to the circumſtance that this ſpecies of alkali very frequently exiſts in the vegetables. However, we ſhould not be too haſty in concluding, from their never yet having been found pure in vegetable ſubſtances, that they may not ſtill be found in them in that ſtate. Citizen Deyeux already aſſures us, that he has obſerved the not-acidulous oxalic acid iſſuing from the pores of the fibres of chich-peaſe, *cicer arietinum*; and this diſcovery is ſufficient to announce, that new reſearches may hereafter increaſe our ſtock of knowledge relative to this ſubject; but it is no leſs true, that in the preſent ſtate of chemiſtry this circumſtance ſeems to be very rare in compariſon with thoſe in which the acidules exiſt.

3. I have already remarked, that only two ſpecies of acidules are hitherto known: the one is termed the oxalic acidule, the other the tartarous acidule; but as each of theſe acidules requires the examination of its pure acid in particular, I ſhall treat under each ſpecies of two varieties, namely, of the native acidule, and of the acid which is extracted from it.

Species I.

Variety I.

Native Oxalic Acidule.

A. *History, Situation, Extraction.*

1. THE name of oxalic acidule is applied to the natural semi-saturated combination of the oxalic acid with pot-ash; it is what was termed, previous to the establishment of the nomenclature, *salt of sorrel.* It has long been known that several species of this genus of plants, and especially that which is termed wild sorrel, *rumex acetosella*, as well as the plant termed alleluia, *oxalis acetosella*, yield by evaporation a concrete acid salt. Duclos is one of the first who has mentioned it in the Memoirs of the Academy, for 1688; Junker has likewise spoken of it; Boerhaave has carefully described, in his Elements of Chemistry, the process for obtaining this salt, which he has compared with tartar. Margraff first discovered the presence of pot-ash in this acid salt, as well as tartar. Since this illustrious author, the labours of chemists upon this salt have been so far multiplied, as to render its history still much more exact than it was at the period when the chemist

chemiſt of Berlin made his reſearches. Amongſt this claſs M. M. Savary, Wenzel, Wiegleb, Bergmann and Scheele are particularly to be mentioned.

2. The oxalic acid, or ſalt of ſorrel is obtained by expreſſing the juice of the plants which contain it, the ſorrel and the alleluia *oxalis* in full vegetation, evaporating it, and letting this inſpiſſated juice cool ſlowly to the conſiſtence of a thin ſyrup. By this firſt operation, it is depoſited in ſmall cryſtals, or cryſtallized plates of a dirty yellow colour. It is re-diſſolved ſeveral times in ſucceſſion, and each time the ſolution is made to cryſtallize, till the acidule is white and pure. According to the number of operations to which it is ſubjected it has different qualities in commerce. Some chemiſts aſſert, that argil is employed in order to purify this acidule; but the fact is neither confirmed nor probable. One hundred parts of oxalis, in full vegetation, afford, according to Mr. Savary, fifty parts of expreſſed juice, which afford only a little more than one two-hundredth part of acidule in conſiderable purity. In commerce we diſtinguiſh the ſalt of ſorrel of Switzerland, which is the whiteſt and the pureſt, and that of the foreſts of Thuringia which is impure and yellowiſh. That of Switzerland is prepared from the *rumex acetoſella*, or the wood-ſorrel; that of Thuringia is extracted from the *oxalis oxitriphillum*, or *alleluia*.

3. Baunach has defcribed the procefs which is practifed in Swifferland, and, efpecially in the Black Foreft, for extracting the juice of forrel from the *rumex acetofa* of Linnæus. This plant is cultivated in abundance in this country; it is cut in June; it is put in a mortar containing about 300 kilogrammes of juice, and it is pounded with a wooden peftle moved by water. The juice and the dregs are put into large tubs where it is fuffered to reft, water being firft added to it, for feveral days; the whole is fubjected to a prefs fimilar to that ufed for grapes; the marc or dregs is pounded a fecond time, after a frefh quantity of water has been added to it, and it is expreffed a fecond time. All the juice that has been collected is flightly heated and poured into feveral vats; water is added, in which fine argil has been mixed, in the quantity of nearly one hundredth part of the juice; the liquor is decanted, and that which contains the marc is filtrated through fine woollen cloth. The juice thus clarified is put into large boilers of tinned copper; it is gently boiled and evaporated till its furface is covered with a pellicle; it is then poured into earthen difhes, which are placed in cool fituations, where they are fuffered to remain quiet for a month; the liquor is then decanted, and an irregular greyifh falt is found upon the fides of the veffels; the liquor is evaporated a fecond and a third time, and a fmall quantity of argil is added to it. The laft mother water contains

 muriate

muriate and ſulphate of pot-aſh; it is ſtill ſour, and appears to contain another acid. The ſalt is purified by diſſolving it in a ſufficient quantity of water, and cauſing it to cryſtallize. According to the experiments of the author, the juice of ſorrel yields a little leſs than $\frac{1}{100}$ of its weight of purified acidule.

4. The oxalic acid may be formed in the direct way, as it was firſt formed by Scheele, by combining with the artificial oxalic acid already indicated, and which ſhall ſoon be deſcribed, about one-fourth part of its weight of pot-aſh: this is an experiment which is performed with ſucceſs daily in the laboratories of chemiſts; by throwing a little liquid pot-aſh into a concentrated ſolution of oxalic acid, ſmall cryſtals of acidule are ſoon precipitated.

B. *Phyſical Properties.*

5. The pure oxalic acidule of commerce is in ſmall white needled or lamellated cryſtals. Capeller and Ledermuller have repreſented them by the microſcope; nevertheleſs their form has not yet been very exactly determined. Romé de Liſle has defined them as conſiſting of very elongated parallelopipedons. When we break them, we perceive in them groups of leaves or plates applied one above the other: it is always of an opaque, and not very brilliant white colour, except in the ſmall fragments which are ſeparated by the fracture.

6. Its

6. Its tafte is four, pungent, and a little acerb; it ftrongly fets the teeth on edge; it is not mixed with any foreign tafte, being neither bitter nor acrid; it is not difagreeable, but on the contrary pleafant and cooling; it ftrongly reddens blue vegetable colours; it is very brittle; is eafily reduced into a very dry powder; it crackles and decrepitates in the fire, but cannot be fufed without a more or lefs confiderable alteration in its principles.

C. *Chemical Properties.*

7. If we expofe oxalic acidule upon an ignited coal, it fwells but little; it exhales, almoft without becoming coloured, a very pungent and very four fmell; it leaves fcarcely any coal, and appears to fublime. Before the blowpipe it quickly difappears, and leaves only a little alkaline afhes, after having been treated in this manner. Four hundred and eighty parts of this acidule were diftilled in a glafs retort, by a well-regulated fire, by Mr. Wiegleb; they yielded one hundred and fifty parts of a very acid water, without fmell and without colour. There remained 160 parts of a grey refiduum, from which were extracted 156 of pot-afh; about four parts of a concrete acid were fublimed into the neck of the retort; not a drop of oil paffed over. Mr. Weigleb has made no mention of elaftic fluid; but it is eafy to conclude

conclude from the 166 parts of lofs, which he had in his operation, that carbonic acid gas and a little water were difengaged, which he did not collect. The acid obtained in this diftillation appears to be pure oxalic acid; whence it follows, that the acidule does not undergo any ftrong alteration by this treatment, and that it is only in part feparated from the pot-afh.

8. The oxalic acid does not fuffer any alteration by the air; when expofed to it, it remains dry and cryftallized, without either its form, confiftence, or colour being changed. It is very foluble in water: according to M. Wiegleb, one part is diffolved in fix parts of boiling water; but he adds, that it is almoft intirely precipitated by cooling, notwithftanding the addition of fix more parts of cold water. Mr. Wenzel carries its folubility ftill farther, fince, according to him, boiling water takes up more than two-thirds of its weight: cold water, however, takes up or retains about a thirtieth part of it. Boiling water, which diffolves it fo much more abundantly, fuffers it to feparate in cryftals, by very flow refrigeration. It is purified and obtained well cryftallized by this procefs.

9. The cold and faturated folution of oxalic acid has a four, pungent tafte that fets the teeth on edge; it reddens the blue vegetable colours. When kept for a long time it cryftallizes regularly without being decompofed or its nature

changed;

changed; this preſervation, or exemption from ſpontaneous decompoſition, is one of the diſtinctive characters of this acidule, by which it is moſt diſtinguiſhed from the ſecond ſpecies, or the tartarous acidule, which, like many vegetable acids, is ſuſceptible of alteration, and entirely loſes its acidity. Citizen Berthollet has well deſcribed the decompoſition of the latter, and the non-decompoſition of the oxalic acidule, in a Memoir, the principal reſults of which I ſhall preſent to the reader.

10. The acids decompoſe, though with difficulty, the oxalic acidule, which is nothing but the acidulous oxalate of pot-aſh; according to Mr. Wiegleb, by heating this acidule with ſulphuric acid, the diſengagement of its acid is promoted; the nitric acid alſo ſeparates it, according to the experiments of Margraff, but in a very different manner than it does the tartarous acid from its acidule; it was by this proceſs that he proved the preſence of pot-aſh in both of theſe acidules. The muriatic acid effects the ſame decompoſition, though with more difficulty, and leaves muriatic acid in the liquor. Theſe decompoſitions, however, are effected only by the aid of heat; in the cold none of theſe acids ſeparates the acid from its acidule; which is owing to its attraction for the pot-aſh.

11. Several earthy and alkaline baſes unite with the oxalic acidule without decompoſing it, and

and caufe it to pafs into the ftate of a trifule or triple falt. Such particularly are barites, magnefia, foda, and ammonia. The triple oxalates have not yet been examined with the attention requifite for determining their characteriftic properties. Pot-afh forms with it faturated oxalate of pot-afh, which fhall be defcribed hereafter. Lime decompofes it by feizing the whole of its acid, both that which is free, and, as it were, infulated, and that which is more engaged in the portion of pot-afh which it contains. Chalk, or carbonate of lime, effects the fame decompofition: it has been afcertained that 100 parts decompofe 137 parts of oxalic acidule, that 175 parts of precipitated oxalate of lime, are obtained, and that the fupernatant liquor yields thirty-two parts of carbonate of pot-afh. This decompofition proves that lime has a ftronger attraction for the oxalic acid, and feparates it from pot-afh.

12. The oxalic acidule decompofes all the calcareous falts, the fulphate, the nitrate, the muriate, the phofphate, becaufe its acid has a ftronger attraction for lime than thofe acids have; accordingly, it may be generally applied to afcertain the exiftence of thofe kind of falts, and even their proportion or their quantity. I fhall fpeak again more fully concerning this important fact, in treating of the pure oxalic acid.

13. The oxalic acidule attacks iron, lead, tin, zinc, and antimony, but does not affect the other metals; it diffolves almoft all the metallic

metallic oxides with which it forms triple ſalts, almoſt all cryſtallizable, and not deliqueſcent, by combining with them intire and without loſing its pot-aſh. The properties of theſe very ſingular ſalts have not yet been ſufficiently examined. As the ſame acidule in ſolution precipitates the nitric ſolutions of mercury and ſilver into inſoluble metallic oxalates, Bayen, by examining the ſupernatant liquors of thoſe precipitations, and finding in them nitrate of pot-aſh, has confirmed, by this eaſy and ſimple operation, the preſence of that alkali in the ſalt of ſorrel.

14. I have here indicated only the chemical properties that belong to the acidulous oxalate of pot-aſh, or the oxalic acidule, ſuch as it is extracted from ſorrel and ſome other plants, under the name of ſalt of ſorrel: from theſe I have carefully ſeparated all thoſe that depend ſolely upon the pure oxalic acid, as I ſhall ſhow in the hiſtory of the latter in particular. According to the analyſes that I have quoted, the oxalic acidule contains more than one-third of pot-aſh; the reſt of its weight is formed of oxalic acid and water.

D. *Uſes.*

15. The ſalt of ſorrel is eſpecially employed for taking out ſpots of ink from white piece-goods, by reaſon of the very ſolvent action which it exerts upon the gallate of iron. It is alſo

alſo uſed in the treatment of diſeaſes in the form of a cooling drink, by triturating it with ſugar, and adding to it a few drops of volatile oil of lemons. The experiments of Citizen Berthollet have ſhown him that the oxalic acidule preſerves fleſh better from corruption than the tartarous acidule; ſo that it has appeared to him that the ſalt of ſorrel might be employed as an antiſeptic with much better ſucceſs than cream of tartar. In chemiſtry, the oxalic acidule is treated, in order to aſcertain its character or properties, and ſometimes to extract the oxalic acid from it, as I ſhall proeeed, to ſhow.

Species I.

Variety II.

Oxalic Acid.

A. Hiſtory, Situation, Extraction.

1. ONE of the moſt beautiful and moſt remarkable parts of the hiſtory of vegetable chemiſtry is that which relates to the diſcovery of the oxalic acid. This acid had long remained, as it were, concealed in the ſalt of ſorrel, which had always been confounded, before Bergman and Scheele, with tartar and its acid. When the former of theſe chemiſts had diſcovered, in the year 1776, the converſion of ſugar into a very

a very ſtrong acid by means of nitric acid, Scheele diſcovered ſome years after, in 1784, that this artificial acid exiſted ready formed in the ſalt of ſorrel, which contained it intire; that Bergman's acid of ſugar might be converted into ſalt of ſorrel, by combining a little pot-aſh with it, and that we may extract from the native ſalt of ſorrel an acid perfectly ſimilar to that which Bergman had prepared from ſugar. This is the reaſon why, on account of this identity, ſince confirmed by all chemiſts, this acid has been termed the oxalic in the methodical nomenclature.

2. The following is the proceſs by which Scheele ſucceeded in extracting from ſalt of ſorrel the pure acid which is contained in it, and ſeparating it from the pot-aſh. The oxalic acidule of commerce is ſaturated with ammonia, by which means a triple ſalt is formed, an oxalate of pot-aſh and ammonia, very ſoluble in water; into the ſolution is poured nitrate of barites alſo diſſolved; a precipitate of oxalate of barites, inſoluble in cold water, is formed, and the ſupernatant liquor retains nitrate of pot-aſh and nitrate of ammonia in ſolution. We are obliged to proceed in this manner in order to ſaturate the free portion of the oxalic acidule with ammonia, which would not otherwiſe decompoſe the nitrate of barites, becauſe it precipitates it only by double attraction. The precipitated oxalate of barites is then well waſhed, and decompoſed by ſulphuric acid which

has

has much more attraction for barites than the oxalic acid has; the ſulphate of barites which is formed, remains inſoluble at the bottom of the liquor: this is decanted; it is tried by a boiling ſolution of oxalate of barites, in order to ſeparate from it any portion of ſulphuric acid that may ſtill exiſt in it, and when it no longer forms any precipitate by the addition of this ſolution, the liquid, which then contains the pure oxalic acid, is ſeparated or filtrated: by evaporating this liquid to a proper conſiſtence, it furniſhes, on cooling, priſmatic or needled cryſtals of this acid. We may alſo obtain it by ſaturating the oxalic acidule with pot-aſh or ſoda; by pouring the ſolutions of theſe triſules into a ſolution of nitrate of barites, and afterwards decompoſing the oxalate of barites which is precipitated, by the ſulphuric acid.

3. It is ſufficiently known from what I have already ſhown in ſeveral of the preceding articles, that we may form oxalic acid in a direct way with gums or ſugar, treated with the nitric acid beyond the formation of the mucous and malic acids for the firſt, and only of the malic acid for the ſecond of theſe bodies. We ſhall ſoon ſee that a multitude of other vegetable matters, and even of animal ſubſtances, are capable of affording, more or leſs abundantly, the ſame acid in a very pure ſtate, by the action of the nitric acid. It muſt here be added, that this artificial fabrication is frequently more economical and

more

more eaſily practiſed than the extraction of this acid from the ſalt of ſorrel, becauſe the latter is always very dear in commerce, and in the artificial formation it is only the acid of nitre which is expenſive.

4. Citizen Deyeux has found in the fibres of chich-peaſe, a conſiderable quantity of oxalic acid. After having cut off theſe fibres with ſciſſars at different lengths, thoſe which had remained almoſt intire, ſoon ſhowed a ſmall drop of liquor at their extremity; thoſe that had been ſhortened by one half, took a longer time before they exhibited this effect; and laſtly, the filaments that had been cut off near their origin, did not preſent any exfudation till after a lapſe of 24 hours. When examined with a ſtrong magnifying glaſs, the divided fibres preſented an orifice, the interior part of which was moiſt, conſequently poſſeſſing vegetation. Theſe fibres were then aſcertained to be ſecretory organs, in which was formed a liquid which, by its ſuperabundance, produced a ſmall drop at their extremity. In fact, had they been merely excretory canals, the liquor would have appeared ſooner at the extremity of the divided veſſels. Beſides, Citizen Deyeux found it impoſſible to diſcover the preſence of the ſame liquid in the parts ſituated the neareſt to the place from whence the hairs took their riſe. The author, after having well examined the phenomenon of the production of this humour, has occupied himſelf with inveſtigating its nature. He firſt obſerves, that

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ſeveral chemiſts, and particularly Mr. Prouſt, had announced that it was acid, and that it burned the ſhoes of perſons who walked over a field of chich-peaſe. Citizen Deyeux, having agitated intire plants, the fibres of which were provided with ſmall drops of humour in diſtilled water, found, on examining this water, that it was charged with pure oxalic acid, and not in the acidulated ſtate. This is the firſt time that this acid has been found pure and inſulated in vegetables. There is reaſon to believe that by multiplying the ſame obſervation and the ſame chemical examination upon plants from which acid humors ſpontaneouſly flow, and which are much more numerous than is generally imagined, this acid will be found in greater abundance than has been ſuſpected. It is evident how important it would be to confirm the diſcovery of Citizen Deyeux by new reſearches.

B. *Phyſical Properties.*

5. THE oxalic acid cryſtallizes in tetrahedral priſms, the ſides of which are alternately broad and narrow, and which are terminated at each extremity by a dihedral ſummit. When the cryſtallization is very rapid, we obtain only ſmall needles without any determinate form. Sometimes it preſents itſelf under that of ſquare or ſlightly rhomboidal plates.

6. It

6. It has an acid and very pungent taſte; we ſhould be inclined to think, on taſting it, that it acted as a powerful and cauſtic acid; nevertheleſs it produces no ſuch effect upon our organs. It is very agreeable when diluted with water; the teeth are ſtrongly ſet on edge by its contact, and it ſoftens and even diſſolves them, like all the oſſeous ſubſtances, by a contact of ſome continuance. Accordingly, ſome modern phyſicians, amongſt thoſe who have begun to apply the lights of chemiſtry to medicine, and, in particular, Citizen Bonhomme, of Avignon, have thought that the ſoftening of the bones in the diſeaſes of children, characterized by the ſoftneſs and crookedneſs of the bones, was owing to oxalic acid formed ſpontaneouſly in their ſtomachs.

7. The acidity of this acid is ſo powerful, that three decigrammes are ſufficient to communicate a very ſenſible acidity to a kilogramme of water; it alſo manifeſtly reddens all the blue vegetable colours: one part of concrete oxalic acid gives to 3600 parts of water the property of reddening paper coloured with the tincture of turnſole.

C. *Chemical Properties.*

8. THE oxalic acid, expoſed to the fire, is in part volatilized in the liquid form, and even in the ſolid and cryſtalline form; only a portion of

of it is decompofed at the higheft temperature, and this portion paffes into carbonic acid and water; only a very fmall quantity of coal remains in the retort. The refiduum is greyifh, and contains carbonate of pot-afh with a little charcoal. The following are exactly the phenomena which the cryftallized oxalic acid prefents when it is heated by degrees. Expofed to a gentle fire it dries, becomes covered with a white cruft, and is foon reduced into powder; it lofes three-tenths of its weight. Placed upon an ignited coal, it is exhaled in acrid irritating fumes, and leaves only a white alkaline refiduum, without coaly matter; diftilled in a crucible, with a ftrong, though moderate fire, it is fufed, becomes brown, boils, and yields an acidulous phlegm, is in part fublimed without alteration, and at laft affords a little carbonic and carbonated hidrogen gas. By heating it very ftrongly, we obtain more of the gafeous product, and of acidulous water, with lefs of concrete acid: the grey mafs which remains at the bottom of the retort is a mixture of carbonate of pot-afh and coal; it is very remarkable that this acid affords no oil in its decompofition by fire.

9. The oxalic acid when expofed to moift air, appears to be deliquefcent; neverthelefs it becomes pulverulent in hot and dry air; it eafily diffolves in cold water, which takes up the half of its weight. When cryftals of oxalic acid are thrown into cold water, they emit a flight found,

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which announces the ſeparation of their molecules from each other. The ſpecific gravity of this cold ſolution is greater than that of diſtilled water by more than one half. By evaporating this liquor none of the acid is raiſed, even by ebullition. Boiling water diſſolves a quantity of it equal to its own weight, half of which is ſeparated from it by cooling: by performing this operation with caution this acid may be obtained well cryſtallized.

10. The acids with ſimple radicals, act upon the oxalic acid with greater difficulty than upon the other preceding vegetable acids. The concentrated ſulphuric acid turns it brown, and converts it into coal with the aid of heat. The nitric acid decompoſes it by ebullition: it has been ſaid to convert it into vinegar; but this is not probable, for this acid, on the contrary, very eaſily reduces it into water and carbonic acid. This laſt reſult is conſtantly obtained by employing a ſufficient quantity of nitric acid, and heating the mixture for a ſufficient length of time. Citizen Vauquelin and I have found in our inveſtigations, that 100 parts of oxalic acid contain 77 parts of oxigen, 13 of carbon, and 10 of hidrogen; ſo that it is one of the moſt oxigenated acids in exiſtence; and this is the reaſon why it can only be decompoſed totally.

11. The oxalic acid forms with barites a ſalt of little ſolubility, which yields irregular cryſtals, when it is diſſolved in water with

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an excefs of oxalic acid. When we wifh to diffolve thefe cryftals in boiling water, this fluid takes from them the excefs of acid which they contain, and renders them opaque, pulverulent and infoluble. The properties of the oxalate of ftrontian are not yet known. Citizen Vauquelin has obtained it by pouring oxalate of pot-afh into muriate of ftrontian. It appears to be infoluble and compofed of 0,59 and a half of earth and 0,40 and a half of acid.

12. Saturated with lime, the oxalic acid forms a falt infoluble in water, pulverulent, which is not decompofable by fire, becaufe the attraction of this acid for lime is fo ftrong, that it takes it away from all the other acids. This oxalate of lime turns the fyrup of violets green.

13. The oxalic acid eafily diffolves alumine. This folution when evaporated yields a yellowifh, tranfparent, fweet mafs, a little aftringent, deliquefcent, and reddening the tincture of turnfole. This falt fwells in the fire, lofes its acid, and leaves the alumine a little coloured. The powerful acids decompofe it.

14. The combinations of the oxalic acid with zircon and glucine have not yet been examined.

15. The oxalic acid may be united with potafh in two ways, either in fmall quantity, or in fufficient abundance to faturate it entirely. In the firft cafe the falt of forrel, the oxalic acidule, or the acidulous oxalate of pot-afh, is

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regenerated. It is in this fact that the brilliant discovery of Scheele consists. On the one hand, he has proved that we can extract from the salt of sorrel, by the process which I have described, a pure, crystallizable acid, in every respect similar to that which is fabricated in the direct way with gum or sugar and nitric acid. On the other hand, he has confirmed his discovery by showing that the acid artificially formed, when united with a little pot-ash, again produces real salt of sorrel; and in fact, if we only pour a little solution of pot-ash into a solution of pure oxalic acid, we see a very speedy deposition of small crystals, little soluble, namely, of oxalic acidule or salt of sorrel. But in the second case; that is to say, when we saturate the oxalic acid with pot-ash, we have a salt very soluble, difficult to be crystallized, assuming the gelatinous form, which crystallizes in hexahedral prisms with dihedral summits when an excess of pot-ash is added to the liquor. This oxalate of pot-ash is decomposable by fire, and by the mineral acids, which speedily precipitate its solution into acidule; it is capable of forming again the salt of sorrel or acidule by an excess of oxalic acid. It is also decomposable by barites and by lime, which precipitate from its solution, insoluble oxalates of these two bases.

16. The oxalic acid is also capable of forming a species of acidule when combined with a small quantity of soda; but when saturated with

with it, it conſtitutes an oxalate of ſoda very difficult to be obtained cryſtallized, more ſoluble, however, in hot than in cold water, turning the ſyrup of violets green, and which comports itſelf in many reſpects like the oxalate of pot-aſh, with the acids, with ſimple radicals, with its own acid, with lime and with barites. Pot-aſh decompoſes this oxalate of ſoda.

17. Combined with ammonia in ſmall quantity, the oxalic acid equally forms a ſpecies of acidulous oxalate, little ſoluble, and cryſtallizable of which we may, like the two preceding acidules of pot-aſh and of ſoda, ſaturate the exceeding portion of acid with other baſes, and conſequently form a kind of triple ſalts. It was by the ſame order of complicated attractions, that Scheele by ſaturating the ſalt of ſorrel, or the native oxalate of pot-aſh, with ammonia, formed a triple ſalt, which he afterwards decompoſed by the nitrate of barites, in order to obtain, the pure oxalic acid. But if we entirely ſaturate the oxalic acid with ammonia, a neutral ammoniacal oxalate is obtained, which yields by evaporation beautiful cryſtals in tetrahedral priſms terminated by dihedral ſummits, one of the ſides of which, being much broader than the other, intercepts three ſides of the priſm. This ſalt is decompoſable by fire, which diſengages the carbonate of ammonia, and leaves only ſome ſlight traces of coal; and alſo by barites, lime and ſtrontian, which ſeparate the ammonia in the ſtate of gas, and precipitate its ſolution into

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infoluble earthy oxalates; and by magnefia, which unites with a part into a triple falt; and by the two fixed alkalis which form foluble oxalates. The oxalic acid precipitates it into cryftals of ammoniacal acidulous oxalate; the powerful acids with fimpler unknown radicals feize the ammonia; the oxalates of pot-afh and foda unite with it into triple falts. It precipitates all the calcareous falts, and it is one of the beft re-agents that can be employed for afcertaining in any liquids the nature and the proportion of thefe falts.

18. We muft add to thefe details relative to the earthy and alkaline oxalates, that all fuch of thefe falts as have confiderable folubility in water, the latter more efpecially, which appear to be very decompofable, do not undergo any fpontaneous alteration in their folution; that they may be ufed with advantage, under this relation, not only for determining the prefence and the quantity of thefe falts, but alfo for decompofing the acidulous phofphate of lime; and that in order to obtain from this all the quantity of phofphate which it contains, the ammoniacal oxalate muft efpecially be employed, as its oxalic acid, by feparating all the lime, with which it is precipitated into an infoluble calcareous oxalite, leaves in the fupernatant liquor ammoniacal phofphate, which as is well known is very decompofable by charcoal.

19. According to Bergman, the attractions of the oxalic acid for the earthy and alkaline bafes

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are to be difpofed in the following order: lime, barites, magnefia, pot-afh, foda, ammonia, and alumine. Thofe of zircon, ftrontian, and glucine have not been afcertained.

20. The oxalic acid decompofes in part all the falts that have pot-afh for their bafe, and forms in their folutions oxalic acidule, which is precipitated in fmall cryftals. By continuing to pour oxalic acid into thefe folutions, after having decanted them from each cryftalline precipitation, we at laft entirely decompofe thefe falts, fo great is the tendency which this acid has to take away pot-afh from the other bafes. The fame refult is not fo eafily obtained with the falts of foda and ammonia, though they alfo experience a decompofition, and yield part of their bafes to this acid. It decompofes all the carbonates, and expels the acid from them with effervefcence.

21. The oxalic acid acts upon feveral metallic fubftances, efpecially thofe that are capable of decompofing water; it unites more or lefs eafily with all the oxides of the metals; it even takes away feveral of them from the moft powerful acids. Excepting tungften, molybdena, chromium, uranium, titanium, and tellurium, which have not yet been combined with the oxalic acid, fome properties of all the other combinations of this acid with the metals have already been indicated. The following is the fummary refult of the knowledge acquired upon this fubject.

A. With

A. With the oxide of arfenic it forms fmall prifmatic cryftals, very fufible, very volatile, and decompofable by heat.

B. With the oxide of cobalt, a pulverulent falt, of a light rofe colour, little foluble.

C. With the oxide of bifmuth, a white falt in powder, very foluble in water.

D. With the oxide of nickel, a falt of a white or greenifh yellow colour, very little foluble.

E. With the oxide of manganefe, a falt in a white powder, which blackens by the action of the fire.

F. With the oxide of antimony, a falt in cryftalline tranfparent grains.

G. It acts upon metallic zinc with efferve-fcence, and difengagement of hidrogen gas; the water is decompofed, and the oxidated zinc combines proportionally with the acid. This oxalate of zinc is in a white powder, and of an acerb tafte, though very little foluble.

H. It does not act upon metallic mercury; but it eafily unites with its oxide, which it whitens by its contact. The oxalate of mercury is in a white powder, which quickly turns black when expofed to the light. The oxalic acid precipitates the nitrate of mercury in a white powder; this precipitate, when heated, fulminates fenfibly, according to the remark of Mr. Packen.

I. Poured upon tin, in plates or in filings, the oxalic acid firft blackens it, and afterwards covers it with a white powder. The oxalate

of

of tin, which is confiderably foluble, has an auftere and metallic tafte. When its folution is flowly evaporated, it yields cryftals in the form of needles or prifms, fufficiently well pronounced. When evaporated more violently, it affords a tranfparent mafs refembling horn.

K. The oxalic acid quickly tarnifhes the brilliant colour of lead; it corrodes it; and diffolves its oxide very well. When faturated with it, its condenfed folution depofits fmall brilliant cryftals, which quickly become opaque by expofure to the atmofphere. The fame acid decompofes and precipitates the nitric folution of lead; if it be poured into this folution a little diluted, it affords cryftals in the fame manner as is done by the immediate union of the oxide of lead. They are alfo obtained by adding this acid to the folution of acetite of lead.

L. This acid ftrongly attacks iron-filings; much hidrogen gas is difengaged from the folution: in proportion as the decompofed water furnifhes oxigen to the iron, this metal unites with the oxalic acid, and forms a folution which quickly becomes reddifh, when heated or expofed to the air. The oxalic folution of iron is very ftyptic; it yields by evaporation prifmatic cryftals of a greenifh yellow colour. The fame acid precipitates the fuperoxigenated falts of iron, and efpecially the red fulphate of this metal, into an oxalate of a fine red colour, which fome chemifts have propofed to to be ufed in painting. There is no acid which diffolves more quickly and more completely the black oxide of iron when in a ftate of great divifion, and efpecially the gallate of iron. It is, therefore, employed with great advantage for taking out ink-fpots, as well as its acidule, or the falt of forrel.

M. The oxalic acid alfo acts eafily upon copper, and produces its green oxidation. It entirely diffolves its different oxides. The oxalate of copper is of a light blue colour, little foluble. The fame acid decompofes and precipitates the fulphate, the nitrate, the muriate, and the acetite of copper: the precipitate is a powder of a blueifh-grey colour.

N. It does not attack metallic filver; but it diffolves, though in fmall quantity, the oxide of this metal precipitated from the nitric acid by pot-afh. When oxalic acid is poured into the nitric folution of filver, we immediately obtain a white, thick, infoluble precipitate of oxalate of filver. We obtain the fame precipitate with any of the foluble oxalates united with the fame folution of filver. This falt is very alterable by the action of light; by expofing it to the rays of the fun, it very quickly turns black. The oxalite of filver formed by this precipitation, when expofed upon coals in a fpoon, is difperfed with a noife, and undergoes a kind of fulmination, according to the experiments of Mr. Packen, confirmed by Citizen Guyton.

O. The

O. The oxalic acid exerts no action upon gold, and it exerts very little even upon the oxide of this metal.

P. It diffolves the precipitate of platina, formed by foda; without affecting the pure metal. The folution of oxalate of platina is yellowifh, and affords cryftals of the fame colour.

22. It is to be remarked, that all the combinations of the oxalic acid with the metallic oxides that have been defcribed by Bergman, from whom I have extracted the facts which I have prefented to the reader, after having verified moft of them, and added to them feveral phenomena fince difcovered, are very eafy to be decompofed by the fire; that none of them affords even a trace of acetous acid in diftillation, whilft all thofe of the citrates furnifh it conftantly, and fome of the latter frequently afford it in fufficient quantity to enable us to fubject it to experiments, and afcertain its nature.

23. All the phenomena which the chemical properties of the oxalic acid prefent, prove, that this acid is more highly oxigenated than thofe of which we have hitherto treated; that it is on this account that it cannot form other acids, or pafs into another acidified nature; that it is the laft term of the vegetable acidification, and that it is no longer fufceptible, by any other oxigenated fubftance, or decompofing procefs, to be decompofed other-

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wise than entirely, and so as to produce carbonic acid and water; that it contains, as we have seen, a small quantity of carbon; that it is on this account that it yields no oil in distillation, and leaves no coal. Accordingly when this acid is formed in the direct way, with sweet, insipid, saccharine and vegetable substances, and nitric acid, we diminish their proportion of hidrogen and carbon, and augment their proportion of oxigen; so that if this action were pushed a little farther, it would entirely destroy the vegetable composition, and reduce it to the last term of its analysis, by reducing it to the state of water and carbonic acid.

D. *Uses.*

24. THE pure oxalic acid is not yet employed either in the arts, in medicine, or for domestic uses. It is, as we have already seen, its acidule, which is employed either for making dry lemonade, and for taking out spots of ink. As yet the pure oxalic acid is prepared and employed only in the operations of chemistry. It is particularly used in order to ascertain the presence and the quantity of the calcareous salts. For this purpose, either the acid alone, or the oxalites are used, especially that of ammonia, which is one of the most sensible and useful. It may be substituted instead of the acidule for taking out ink-spots. It may also be prepared as a drink, by diluting

ing it with a ſufficient quantity of water, and ſweetening it with ſugar or honey. It may become very uſeful, if it ſhould hereafter be found pure, as it probably may, in the juices of acid vegetables.

Species II.

Variety I.

Tartarous Acidule.

A. *Hiſtory, Situation, Extraction, Purification.*

1. THE tartarous acidule, or the acidulous tartrite of pot-aſh, a denomination which exactly deſignates it nature, has long been known by the name of tartar. It is twenty years ſince its nature has been well determined. After Paracelſus and Van Helmont, who had erroneous ideas reſpecting its nature, the labours of a great number of chemiſts were requiſite to bring the knowledge of it to the degree of preciſion which it has now attained, and to afford preciſe notions reſpecting its compoſition. Fizes, Montet, and Citizen Deſmarets have deſcribed the proceſſes by which it is purified. Boerhaave, Neumann, Rouelle the younger, Spielman, Corvinus, Bucquet, have proved that it exiſts ready formed in the juice of the grape, before its converſion into wine. Beguin, Angelus

Angelus Sala, Libavius, Zwelfer, Lefevre, Glazer, and Hierne maintained against many other chemists that tartar contained alkali ready formed. Duhamel and Grosse, Margraff, and Rouelle the younger confirmed this assertion by very exact experiments. Messrs. Wiegleb, Rozensteil, Packen, Bayen and Berniard gave or accumulated by different methods the proofs of the pre-existence of the alkali in this acidule before the action of the fire. After Blaise de Vigenère, Lemery and Neumann, Spielman and Citizen Berthollet have well described the decomposition of this acid by the fire; Corvinus, Citizens Machy and Berthollet, its spontaneous decomposition in water; Scheele, Retzius, Bergman and Packen have given the means of extracting the pure acid from this acidule. Mr. Hermstaedt has carefully examined several properties of this acid. Such is the summary result of the principal investigations that have been bestowed upon the tartarous acid.

2. Though the tartarous acid exists in the juice of the grape, in the tamarind, in sumac, in the tamarisc, in balm, in the carduus benedictus, in the roots of rest-harrow, of germander, of sage, in the fruit of the barberry, and undoubtedly in a multitude of other fruits; it is not from these substances that it is extracted. It is more especially precipitated and deposited from wine kept in casks, and particularly from the wines of France, and those of the Moselle and the Rhine. It forms successive layers which become con-

condenfed almoft like ftony incruftations, and which are collected upon the fides of the barrels or cafks in which thefe liquors are kept. The white and red are diftinguifhed by the name of the *white* and the *red* tartar: but it is very far from being pure any more than the lees which contain a very large quantity of it. In tartar and in the lees, befides the colouring matter which they contain, we alfo find foreign fubftances, kernels, fkins, &c. We likewife find in them fulphate of pot-afh, &c. It is purified in order to feparate thefe foreign matters, by the following proceffes, defcribed by Fizes, Montet, and Citizen Defmarets.

3. This acidule is in fome meafure refined or purified in the vicinity of Montpelier, in the manner in which in general many other faline fubftances are treated. The crude tartar is boiled in water; this boiling folution is filtrated; as it cools it becomes turbid, and depofits irregular cryftals in the form of a pafte. This pafte is boiled a fecond time in copper veffels, with water in which a fat earth dug at the village of Merviel, near Montpelier, has been diffufed. The fcum which rifes is carefully removed; afterwards a faline pellicle is formed, upon the appearance of which the application of the fire is difcontinued; this pellicle is broken, and it precipitates itfelf with the cryftals that have already been depofited: thefe cryftals are wafhed in water, in order to free them from the earth which foils them. They are introduced into com-

commerce under the very improper appellations of *cream* or *cryſtals of tartar.* The cream has been ſo called becauſe it is the part formed at the ſurface; the cryſtals or the ſalt of tartar are thoſe which are found beneath. It has been ſaid that the clay ſerves to free the tartar from the oily matter which was admitted to exiſt in it; but it is evident that it ſerves to ſeparate the colouring and extractive part, to which alumine, as we ſhall ſee hereafter, has a ſtrong attraction: accordingly this earth anſwers the ſame purpoſe here as in the purification of the ſalt of ſorrel; it diſcolors and clears the tartarous acidule by favouring its ſeparation, by even taking away its colouring matter.

4. At Venice, a ſomewhat different method is employed for purifying the tartar. According to Citizen Deſmarets, this acidule is diſſolved in the ſtate of powder, in boiling water; the foreign or impure ſubſtances which it contains are left to ſubſide, and the portion which floats above is taken off. The liquor yields cryſtals by reſt and cooling. Theſe cryſtals are again diſſolved in water which is ſlowly heated; when this ſecond ſolution boils, whites of eggs beat up in water and wood-aſhes paſſed through a ſieve are thrown in; this addition of aſhes is performed fourteen or fifteen times; the ſcum produced by the efferveſcence is removed, and the liquor is then left to reſt. A pellicle of very white ſaline cryſtals is ſoon formed upon it, the water is decanted and the ſalt dried. It is

very evident that this procefs changes the nature of a part of the tartar or of the tartarous acidule, that the pot-afh of the afhes faturates a portion of its infulated acid, as appears from the effervefcence which takes place; that part is converted into the ftate of foluble tartar, and that much of it muft be loft by this procefs. The mother water muft contain tartrite of pot-afh or *vegetable falt*, as it was formerly termed. It is equally evident that the Montpelier procefs deferves the preference.

5. Sometimes the tartarous acidule or the cream of tartar of commerce is purified in laboratories for chemical or pharmaceutical ufes. For this purpofe it is boiled in water; the boiling folution is filtrated; it is left to cool flowly in veffels of glafs, earthen-ware or porcelain; and in this laft purification the acidule is precipitated very white, cryftalline, tranfparent, and extremely pure. This is the manner in which it ought to be prepared for medicinal ufe and for the accurate inveftigations of chemiftry.

B. *Phyfical Properties.*

6. The tartarous acidule when fufficiently pure is in fmall cryftalline fragments, the form of which is difficult to be determined with exactnefs. However, when we carefully obferve the purification of this acidule, we diftinguifh needles, or quadrilateral prifms, truncated in a floping

direction at their extremity. These prisms grouped together produce the irregular masses which form the common cream of tartar.

7. The taste of this acidule is sour, a little disagreeable and not vinous like that of the crude or raw tartar, such as it is taken out of the casks. Its taste is not nearly so acid as that of the oxalic acidule, and it does not set the teeth on edge as that does: accordingly it is not in general so antiseptic as the latter, neither does it preserve food equally well.

8. The tartarous acid is very brittle and pulverizable. As soon as it is heated to softness and incipient fusion, it changes its nature and is decomposed as we shall soon see; it reddens the tincture of turnsole and the syrup of violets.

C. *Chemical Properties.*

9. When the tartarous acidule is exposed upon a burning coal, it becomes soft, fused, inflated, brown, emits sour, pungent, empyreumatic fumes, of a particular and well determined smell: it leaves a voluminous, abundant, heavy, and very alkaline coal. The decomposition of the tartarous acidule by distillation in a retort is one of the operations with which chemists have been most occupied, and upon the products of which they have amply written. This distillation is performed in a retort of stone-ware or cast iron, to which are fitted an adopter

adopter and receiver, provided with tubes proper for conducting and collecting the elaftic fluids; the fire is applied by degrees and with precaution, and at laft pufhed fo far as to render the bottom of the retort perfectly red-hot. There firft paffes over water little coloured, and fcarcely acid, afterwards a liquid acid ftronger and reddifh; then an oil which affumes colour and confiftence in proportion as the heat is increafed, a large quantity of carbonic acid and carbonated hidrogen gas; and at laft carbonate of ammonia which cryftallizes in the adopter.

Amongft all thefe products, each of which deferves to be examined in particular, that which has moft ftruck the attention of chemifts is the enormous quantity of elaftic fluid, which they long conceived to be air. A cubic inch, or 543 grains of tartar of Rhenifh wine, gave Hales 304 inches, or 144 grains, or nearly one third of its weight of elaftic fluid. Citizen Berthollet computes the quantity of gas extricated by diftillation at nearly three quarters of the weight of the tartar. Spielman and Corvinus have calculated that this gas occupies two hundred and forty-four times the volume of the matter employed. Nearly three-fourths of this gas are carbonic acid, and one fourth carbonated hidrogen gas, which burns white or blue, and is mixed in two or three varieties, according to the quantity of carbon, or of intire oil, diffolved in this gas.

The oil which forms, according to Lemery and Spielman, about one ſixth of the weight of the tartar, is one of the products of this diſtillation which differs the moſt from thoſe of the preceding acidule; it manifeſtly proceeds from the much larger proportion of carbon and hidrogen contained in the tartarous acid than in the oxalic. It was formerly rectified for the purpoſe of preparing a ſtrengthening external remedy, which was in high eſteem. It is evident that it did not exiſt ready formed in the tartar, but that it reſults from the particular union of a certain quantity of hidrogen and carbon; accordingly, it varies as well that as of the acid phlegm and the gaſes, according to the manner in which this diſtillation is conducted, and the rapidity and force of the fire that is applied.

Ammonia in the ſtate of concrete carbonate, indicated amongſt the products of this operation by Lemery, Juncker, Wiegleb, and eſpecially Bucquet, announces that the tartarous acidule contains azote amongſt its primitive principles. A portion, according to thoſe authors, is combined with the liquid acid, of which I ſhall ſoon ſpeak: but I muſt here obſerve that ſome modern chemiſts do not reckon ammonia amongſt the number of the products of the decompoſition of the tartarous acidule, and think that he was deceived by a ſmall quantity of pot-aſh, elevated at the ſame time as as the liquids and the gafes that are difengaged. This fact, therefore, deferves to be verified by new experiments more exact than thofe that have hitherto been made; for it may lead us to determine whether it be not at the expenfe of the pot-afh, as was formerly thought, that this volatile alkali is formed, and whether this fixed alkali does not furnifh azote which unites with the hidrogen of the decompofed acid.

10. After this decompofition, there remains in the retort a very alkaline and very acrid coal, which attracts the moifture of the atmofphere, which yields much carbonate of pot-afh by mere lixiviation and cold water, and the nature of which ferves to prove the prefence of this alkali in the proportion of one third of the weight of the tartar in the acidule; for at prefent it is no longer believed that the pot-afh is formed by the action of the fire at the expenfe of the total decompofition of the tartarous acid; for this, when pure, as we fhall foon fee, does not afford the alkali in its coal. Chemifts avail themfelves of this property of the coal of tartar, in order to extract from it quickly and by an eafy procefs, a confiderable quantity of fufficiently pure pot-afh. Crude tartar is put, in the ftate of a coarfe powder, into wrappers of thick brown paper, which are immerfed in water; thefe are placed upon a bed of charcoal in a furnace, which is thus fucceffively filled with alternate layers of papers of tartar and coal, care being taken to cover the laft layer

layer with a somewhat thicker stratum of coal. This coal is set on fire, and suffered to become totally extinguished after its complete combustion; when the whole has cooled, the papers are taken out much diminished in volume, as is natural to suppose, but retaining their form, on account of the solidity of the paper and of the water which has agglutinated, and, as it were, united the leaves. These papers contain the pot-ash of the tartar, the coal of which is destroyed; it is combined with a portion of carbonic acid. Excepting a small quantity of lime and sulphate of pot-ash, which are frequently found in this alkali, it possesses a considerable degree of purity. Formerly it was much employed by chemists, under the name of *fixed salt of tartar*, or alkali of tartar. As it contains much pot-ash in an insulated state, it quickly attracts the moisture of the atmosphere, and then forms a thick liquid which was termed *alkali of tartar per deliquium*, oil of tartar *per deliquium*; this last ridiculous denomination has long been laid aside. Three eighths of the tartar are obtained in this alkali.

11. One of the most remarkable products of this decomposition of the tartarous acidule by fire, is the particular acid which passes in the liquid form in distillation, and which is a new production of the mutual re-action of the principles of the acid, effected by the action of caloric; this is the *pyrotartarous* acid. I shall speak of it in detail, in treating of the tartarous

ous acid, which likewiſe affords it by diſtillation; it is ſufficient here to know that it is a modified acid, different from that which exiſted in the acidule, and which, compared with the other products of this igneous decompoſition, ſhows the great diverſity between this acidule and the oxalic acidule. Hence it may be concluded, that this decompoſition, which indicates a great abundance of carbon and hidrogen in the tartarous acidule, authorizes the termination in *ous*, adopted by the methodical nomenclature, and oppoſed to that of oxalic acidule; as this laſt, not being equally decompoſable is much more oxigenated.

12. The tartarous acidule experiences no alteration by the contact of the air; no ſimple combuſtible body, if we except carbon, which purifies or whitens it, exerts any action upon it. It is very difficult of ſolution in cold water, which ſcarcely takes up more than one ſixtieth part of its weight. Boiling water diſſolves nearly one thirtieth, the greater part of which is precipitated, and cryſtallizes by the cooling of the liquor. This ſolution, which is ſouriſh, and of a diſagreeable taſte, reddens the blue vegetable colours. When left to itſelf in a cloſe veſſel, it is decompoſed, and preſents phenomena very different from thoſe which I have deſcribed with reſpect to the oxalic acidule, which does not undergo the ſame decompoſition. Citizen Machy is the firſt who has ſpoken of this decompoſition, by which he

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wiſhed to prove that the alkali was the product of an alteration, and that it was not contained ready formed in the tartarous acidule; but he was miſtaken when he aſſerted that the mucus that was precipitated did not contain alkali, and that the ſupernatant liquor was acid, ſince he has not purſued this decompoſition far enough, nor examined the ſupernatant liquor, which after this decompoſition contains the whole of the pot-aſh pre-exiſting in the acidule. Spielman and Corvinus have committed the ſame error, though they had made a more exact experiment. This ſpontaneous decompoſition has ſince been followed and deſcribed with the moſt care and ſucceſs by Citizen Berthollet; he has given the reſult in a Memoir inſerted amongſt thoſe of the Academy of Sciences, for 1782. After having diſſolved one part of tartarous acidule in ſixty-four parts of diſtilled water, he left this ſolution in a glaſs veſſel covered only with paper, in the natural temperature of his laboratory. The liquor gradually diminiſhed in volume; mucous flakes were precipitated in it, which he did not take away, like Spielman, in order that nothing might be loſt. At the end of five months this mucoſity was very abundant; the liquor was red, but it ſtill reddened the ſyrup of violets, and had a ſour taſte; the mucoſity ſtill augmented; he replaced the water which was evaporated, and after eight or nine months the liquor began to turn the ſyrup of violets green, aſſuming a more and more deep colour. After

this

this ſpontaneous proceſs had been carried on for eighteen months, the liquor not appearing to him to undergo any more alterations, he filtrated it; the mucilage received upon the filtre dried there, loſing much of its volume, and being reduced to a very ſmall weight. After having burned it, its aſhes yielded only ſigns of alkalinity; but the ſupernatant liquid which was ſtrongly alkaline, afforded by evaporation carbonate of pot-aſh rather oily, and this being reduced to coal by the action of the fire, weighed five-eighths of the tartarous acidule originally employed; as did the alkali which he obtained by treating a like doſe of this acidule by diſtillation. According to the chemiſt whom I quote, the tartarous acid decompoſed ſpontaneouſly, and very ſlowly by this experiment, formed the mucous flakes that were precipitated, with the carbonic acid, and the ſmall portion of oil united with the pot-aſh that remained in the liquor, and exiſted ready formed in the acidule. I ſhall ſubjoin to this detail the reſult of another experiment adapted to confirm this theory, and leave no doubt of its accuracy; namely, that the pure tartarous acid, which is equally alterable by a ſlow and ſpontaneous decompoſition, leaves no pot-aſh in the liquor which is the reſiduum of its decompoſition, and that the ſolutions of the alkaline tartrites, in which we know exactly the proportions of alkalis that have been employed for preparing them, leave only theſe alkalis together

together with the carbonic acid and the ſmall quantity of oil, produced by the decompoſition of the acid.

13. The tartarous acidule, which I may equally term *acidulous tartrite of pot-aſh*, as the facts that have already been quoted reſpecting its properties, prove that it is in fact only tartrite of pot-aſh with exceſs of acid, experiences no alteration from any of the acids, unleſs they have ſufficient power to alter the peculiar nature of its acid. The portion of pot-aſh which it contains has more attraction for its exceſs of tartarous acid than any of the acids, even the ſtrongeſt have; and on this account the tartarous acid decompoſes all the alkaline ſalts till it becomes tartarous acidule. Accordingly, when in the experiments of Pott, of Margraff, and of Rouelle the younger, we find theſe able chemiſts ſucceed in extracting the pot-aſh from the tartar, or cream of tartar, by means of the acids termed *mineral*; we are to underſtand that they ſucceeded only by decompoſing the tartarous acid itſelf, and converting it either into acetous or oxalic acid. Thus by throwing one part of concentrated ſulphuric acid upon one part of tartarous acidule in the ſtate of powder, and favouring the action of this mixture, which becomes much heated at the moment when it is made, with the heat of a *balneum mariæ*, continued for ten or twelve hours: the two ſubſtances form a brown magma. By afterwards pouring into them three

three or four times their weight of boiling diſtilled water, ſaturating the ſulphuric acid by means of chalk, filtrating and evaporating the liquor, we obtain ſulphate of pot-aſh mixed with a little ſulphate of lime. But what neither Rouelle nor Bernard have announced is, that acetous acid is formed in this experiment. The ſame circumſtance takes place by the muriatic acid. The nitric acid ſeizes the pot-aſh of the tartarous acidule only by cauſing its acid to paſs into the ſtate of oxalic acid.

14. The boracic acid unites without decompoſition with the tartarous acidule: one part of the firſt to four of the ſecond is ſufficient to render it ſoluble in ſix or eight times its weight of hot water, as Laſſone has ſhown in the Memoirs of the Academy for 1755. It is in this manner that we ought to prepare what has been termed in pharmacy *ſoluble cream of tartar*, and not with borax; for this laſt, which contains much ſoda in exceſs, as I ſhall ſhow on another occaſion, conſtitutes with the tartarous acidule a triple ſalt, a tartrite of pot-aſh and ſoda, mixed with boracic acid, which is very far from being *cream of tartar*. Accordingly, this addition of borax to cream of tartar for the purpoſe of rendering it ſoluble, announced by Lemery, in 1728, in the Memoirs of the Academy; and propoſed in the ſame year, as a remedy, by Lefebvre, phyſician at Uzés, in the ſame academical collection, cannot fulfil the in-

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tentions of the phyſician, like that of the boracic acid alone.

15. Long ago ſeveral of the earthy and alkaline baſes have been combined with the tartarous acidule, in order more eſpecially to prepare from it different kinds of medicines. Chemiſts have examinated ſeveral of theſe combinations for better aſcertaining the nature and the properties of the tartarous acid; and their labours, as we ſhall ſoon ſee, have reciprocally enlightened the art of healing in the preſcription of theſe medicinal preparations: at leaſt, it is from the pharmaceutical ſource of theſe ſaline combinations, which are almoſt always triple, that the diſcoveries which have fixed their nature and properties, have been derived. We muſt therefore accurately deſcribe theſe combinations, conſidering them under the double point of view that has been indicated.

16. The ſolution of barites decompoſes that of the tartarous acidule, ſeizes its acid, with which it forms an inſoluble ſalt, which is precipitated in a white powder, and leaves the inſulated and pure part in the ſupernatant liquor: it is, as we ſee, a good mean of proving the preſence of pot-aſh in the tartarous acidule, and even of determining its proportion. The ſame is probably the caſe with ſtrontian.

17. Lime effects the ſame decompoſition, and even in a ſtill more energetic manner, ſince, according to the order of elective attractions indicated by Bergman, it is more attracted by the

the tartarous acid than barites is. It is to be obferved, that I do not intend here to defcribe the properties of the earthy and alkaline tartrites, which are to be placed in the hiftory of the pure tartarous acid; but that I only confider the action of thefe bafes, as decompofing the tartarous acid, and uniting with it into triple falts. When lime-water is poured into a folution of tartarous acidule, an abundant and pulverulent precipitate of tartrite of lime is produced, and pure pot-afh remains in the liquor. If we take carbonate of lime, as Rouelle has done, this earthy falt acts only upon the free portion of the tartarous acid, with which it alfo forms infoluble calcareous tartrite in proportion as carbonic acid is difengaged. After this, the fupernatant liquor contains the portion of pure and neutral tartrite of pot-afh, with which the tartarous acid was united in the acidule. This is another of thofe fimple and ingenious experiments by which Rouelle the younger proved in an immediate manner the prefence of pot-afh in tartar. He thus feparated from it the neutral falt which was termed at that time *vegetable falt*, and of which I fhall fpeak in detail in the article concerning the tartarous acid.

18. Magnefia does not act in the fame manner upon the tartarous acidule. Though Bergman places it before the fixed alkalis, in his order of attractions for the tartarous acid, it does not appear to be capable of feparating the pot-

pot-ash from this acidule, but rather of remaining united with the acid at the same time with it, and of forming a kind of triple salt. The Chemists of the Academy of Dijon have obtained from the acidulous tartrite of pot-ash, saturated with magnesia, a soluble salt, which yielded them, by its spontaneous evaporation, small aculeated crystals, disposed in rays. Poulletier de la Salle has obtained from the same combination a gelatinous mass, resembling a mucilage.

19. It appears that alumine produces a nearly similar effect with the tartarous acidule, though it unites with it with more difficulty, since, as we have seen above, argil is employed to purify tartar in the vicinity of Montpelier. The action of zircon and glucine upon this acidule is absolutely unknown. Silex does not seem to exert any upon this saline compound.

20. When we combine pot-ash or the carbonate of pot-ash with the tartarous acidule, it becomes saturated entirely with this alkali, and forms the same salt as that which shall be described by the name of tartrite of pot-ash, in the history of the tartarous acid.

21. The same is not the case with soda as with pot-ash: this alkali, by combining with the tartarous acidule which it saturates completely, forms with it a kind of triple salt, which has long been named *Salt of Seignette*, from the name of a pharmaceutical practitioner of Rochelle, who first discovered, prepared, and pro-

propofed it for medicinal ufe. As a *trifule,* namely, *tartrite of pot-aſh and ſoda,* the hiſtory of this falt muſt here be explained.

In order to prepare this falt, one part of fufficiently pure tartarous acidule is thrown into five parts of boiling water, and to thefe is added carbonate of foda cryſtallized and reduced to powder, till no more effervefcence takes place, and till the acidule is completely faturated. In proportion as this faturation is effected, the acidule difappears and diffolves in the liquor; after having drawn it off clear, this is evaporated to the confiftence of a thin fyrup, and fuffered to cool gradually: by this gradual cooling it furnifhes large and very regular cryftals, in prifms of eight fides nearly equal, which are frequently excavated, as it were, in their middle and almoft in their axis; they then refemble a tomb. The broad face upon which they reft then prefents two diagonal lines which crofs each other at the centre. This falt, which at firft was fold as an arcanum, was difcovered in 1731, by Boulduc and Geoffroy, who defcribed its preparation in the fittings of the Academy of Sciences of Paris. Since this period all druggifts have prepared it in their laboratories; it has become much more common and confequently much better known.

When this falt is prepared, as well as the tartrite of pot-afh or vegetable falt, there remains at the bottom of the liquor a kind of earthy refiduum, in the form of clay or pafte, fometimes in that of ſmall needles interwoven with each other. The practitioners of pharmacy, who all know this depoſition, had conſidered it as a ſpecies of earth engaged in the *cream of tartar* of commerce, and ſeparated by the ſoda. Citizen Vauquelin has examined it with care; he has found that it forms about 0,07 of the tartarous acidule, that it is not ſeparated from the pure tartarous acid, that it exiſted only in the *cream of tartar*, and that it is tartrite of lime afforded by the wine; as he has alſo found it in crude tartar. He has ſhown by the ſame inveſtigation, that the ſalt of Seignette contains very nearly 0,54 of tartrite of pot-aſh, and 0,46 of tartrite of ſoda; that thus it is accurately termed *tartrite of pot-aſh and of ſoda*. This triple ſalt has a bitter taſte; it is decompoſed by the fire, and yields pyrotartarous acid, oil, and gas, like all the tartrites; it effloreſces in the air; it is ſoluble in about five parts of water; it is decompoſable in part by the powerful acids which precipitate from it the tartarous acidule; it is entirely decompoſable by barites and by lime.

22. The tartarous acidule combines alſo with ammonia, which ſaturates it into a triple ſalt. This tartrite of pot-aſh and of ammonia affords fine cryſtals, which Bucquet has deſcribed as pyramids; Macquer, as hexahedral priſms, terminated by very ſharp pyramids; the academicians of Dijon as parallelopipedons with two alternate ſlopes. It has a cooling taſte; it

it is decompoſed by the action of fire; it efﬂoreſces in the air; it is more ſoluble in hot than in cold water, and cryſtallizes by cooling. The acids precipitate acidule from it; lime, barites, ſtrontian and the fixed alkalis ſeparate from it either both baſes, or only ammonia.

23. Though, in general, there is little reciprocal action known between the ſalts and the tartarous acidule, it is probable that there would take place between them, eſpecially thoſe with an earthy baſe, a great number of effects of double attractions, which it would be uſeful to appreciate. The nitrates and the ſuperoxigenated muriates decompoſe it with the aſſiſtance of heat, decompoſe or burn its acid, more or leſs completely according to the proportion of theſe ſalts which is added to it. With the nitrate of pot-aſh and crude tartar is prepared an alkali, or rather a carbonate of pot-aſh, which was formerly termed in chemiſtry *white flux*, or *black flux*, accordingly as the one contained only the alkaline carbonate by reaſon of the complete combuſtion of the carbon, and as in the other there remained a portion of the carbon of the tartar. Theſe names of fluxes have been given to the products of theſe operations, becauſe they have been eſpecially deſtined to ſerve for fuſing the earths of the gangues in the aſſaying of ores. The black or reducing flux is formed with two parts of tartar and one part of nitre; the white with equal parts of tartar and of nitre, the mixtures being thrown into a red-hot cruci-

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ble, in which they detonate and inflame with rapidity. The combuſtion and detonation of the ſecond is much ſtronger than that of the firſt. The term of *crude flux* is applied to the mixture of nitre and of tartar in whatever proportions before it has been made to detonate.

24. The tartarous acidule appears to be capable of uniting with moſt of the metals, and eſpecially of the metallic oxides, without being decompoſed, according to the experiments of Citizen Monnet and the academicians of Dijon. It conſtitutes a kind of triple ſalts. Hitherto thoſe only have been examined with attention that take place with the oxides of antimony, of mercury, of lead and of iron; either becauſe theſe compounds preſent a greater number of remarkable facts, or becauſe moſt of them are medicines of more or leſs importance; that which merits the moſt attention of all, which is ſo generally employed that it might be ſaid to conſtitute a kind of univerſal remedy, is its union with the oxide of antimony.

25. The names of *ſtibiated tartar*, *antimoniated tartar*, *tartar emetic*, have been applied to the triple ſaline combination of the tartarous acidule, and the oxide of antimony. Adrian de Mynſicht was the firſt who gave an account of it, in 1631. Almoſt all chemiſts have zealouſly occupied themſelves with it; but none of them have examined its properties with more attention than Bergman. Every author and every pharmacopoeia has given particular pro-

processes for preparing this important medicine. They differ from each other, both with respect to the species of oxide of antimony which they propose, with respect to their quantity, and that of the water, or of the tartarous acidule, and lastly with respect to the manner of proceeding in its preparation. Bergman, in his Dissertation, has given a very well constructed table of all the processes hitherto described for this preparation. The sublimed white oxides and the vitreous sulphureous oxides have been successively recommended. Some have prescribed ebullition with the tartarous acidule and water for the space of ten or twelve hours; others have indicated only an ebullition of half an hour. Some have recommended to evaporate the filtrated lixivium to dryness; others have prescribed to cause it to crystallize, and to use only the crystals. Accordingly as these different processes have been adopted in different pharmaceutical laboratories, salts very different in their nature and their virtues have been obtained. Thus Geoffroy by examining different stibiated tartars, found them to contain from one-eighteenth to upwards of one-fourth of their weight of oxide of antimony. After a great number of trials, most able chemists have preferred the vitreous sulphurated oxide of antimony, or the *glass of antimony*, to all the other oxides, as it is one of the most soluble by the tartarous acidule. It is boiled with an equal quantity of tartarous acidule, both reduced to powder, in a fufficient quantity of water, namely, eight or ten times their weight, till the acidule is faturated; there rifes a confiderably thick fcum, charged with yellowifh or brown flakes, which are a mixture of fulphur, of tartrite, of lime, and of a little oxide of antimony. Frequently this fcum forms a magma, as it were gelatinous, which yields a pyrophoric refiduum when diftilled. The liquor, which is of a very clear lemon colour, is filtrated; then evaporated with a gentle heat till a flight pellicle is formed, and fuffered to cool flowly; regular cryftals are formed, which are extracted from it at feveral times by fucceffive evaporations. Some chemifts prefer the oxide of antimony precipitated from the fublimed muriate by water, or the grey fulphurated oxide, for this preparation.

26. This compound is a triple falt, or a tartrite of pot-afh and antimony, which cryftallizes in regular tetrahedrons or triangular pyramids, or in octahedrous more elongated than thofe of alum. It has a flightly metallic and harfh tafte: fire decompofes it, difengages from it pyrotartarous acid, and leaves a coal which contains pot-afh and oxide of antimony, and which frequently takes fire by the contact of the air. This falt effloresces in the air, lofes its tranfparency, and becomes of a dull white colour, very brittle and pulverulent. It is foluble in eighty parts of water at fifteen degrees. Boiling water diffolves above one half more of

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it. The ſolution ſlightly reddens the tincture of turnſole. The earths and the alkalis ſeparate from it a very white oxide of antimony: the alkaline carbonates, a carbonate of antimony in ſmall needled cryſtals, diſpoſed in rays. The alkaline ſulphurets and the hidro-ſulphurets form in it a precipitate of an orange colour, or a *ſulphur auratum*, the colour of which renders it eaſy to recognize the preſence of this antimoniated ſalt. The juices of plants, and eſpecially the extractive decoctions of the woods, the roots and the barks, precipitate the ſolution of tartrite of pot-aſh and antimony into a matter of a reddiſh-yellow colour, which has no longer an emetic quality; and Citizen Berthollet has propoſed to deſtroy, by means of a decoction of Peruvian bark, the bad effects of this ſalt received in too large quantity, or inconſiderately into the ſtomach. Several metals, and particularly iron, decompoſe the tartrite of pot-aſh and of antimony, and precipitate the latter oxide. Bergman aſſerts that it contains nearly a third of its weight of antimony.

27. The tartarous acidule may be combined in two ways with the oxide of mercury; for it has only a feeble action upon this metal, of which it only favours the oxidation into the black ſtate, or the ſimple extinction. The firſt conſiſts according to the proceſs of Citizen Monnet, in treating with boiling water, ſix parts of tartarous acidule, and one part of oxide of mercury precipitated

precipitated from the nitric acid by the carbonate of pot-afh. The filtrated liquor yields by evaporation fmall cryftals of tartrite of pot-afh and of mercury. However this falt is of little permanency, for the fame author afferts that it is fufceptible of being decompofed by pure water. The fecond method confifts in pouring a folution of tartrite into the nitric folution of mercury; but here only a fimple tartrite of mercury is precipitated, and no triple falt is formed, as in the preceding cafe; the compound formed, belongs therefore to the hiftory of the tartarous acid, not to that of the acidule.

28. A very fenfible action takes place between the tartarous acidule and the oxides of lead. Rouelle the younger, has verified, that thefe oxides have the property of decompofing the tartarous acidule, of taking from it its excefs of acid, and of uniting with it into a tartrite of lead, white, pulverulent, and infoluble; of leaving in the fupernatant liquor the tartrite of pot-afh, which exifted in the tartarous acid: accordingly this chemift has employed this fact for confirming the prefence of pot-afh in this acidule.

29. It appears, that the tartarous acidule eafily attacks copper and its oxides, and that the refult is a triple falt of a fine green colour, fufceptible of cryftallization, which has hitherto been but little examined.

30. Iron is one of the metals upon which this acidule acts with the moft energy, and with which

which it forms ſeveral compounds deſigned for medicinal uſe. The *chalybeated tartar* is prepared by boiling in 92 parts of water, four parts of iron filings, and ſix parts of tartarous acidule. When the acidule appears to be diſſolved, the liquor is filtrated; it depoſits cryſtals, and others are obtained from it by continuing the evaporation. The *tartarized tincture of Mars* is the product of a paſte made with ſix parts of iron filings ſixteen parts of tartarous acidule, and a ſufficient quantity of water, which is left at reſt for twenty-four hours, and is afterwards boiled in 92 parts of water for two hours, till it is evaporated to the conſiſtence of a ſyrup, one part of alcohol being added at the end. It appears that this latter medicine is not a triple ſalt, as Rouelle aſſerts, but that the pot-aſh exiſts in it in a free ſtate, and that by treating it with the acids it affords the ſalts which that alkali always yields. There are alſo prepared what are termed *ſteel-balls (boules de Mars)*, by putting one part of ſteel-filings, and two parts of white tartar, in the ſtate of powder, into a glaſs veſſel with a certain quantity of ſpirit of wine. When this is evaporated, the maſs is pounded, ſpirit of wine is added, as at firſt, and it is left to dry. This proceſs is repeated till the mixture becomes fatty and tenacious: it is then formed into balls.

D. *Uſes.*

D. *Uses.*

31. THE tartarous acidule, under the form of crude tartar, white or red, is employed in many of the arts, eſpecially in dyeing, in the felting of hats, in gilding, in docimaſtic proceſſes, &c. In chemiſtry it is an extremely uſeful ſubſtance, as I have already ſhown.

32. In medicine, the purified tartar, or the tartarous acidule, is much employed under the name of *cream of tartar*, as a refrigerant, an antiſeptic, and a gentle purgative. It is frequently rendered ſoluble by the addition of borax, or boracic acid. It cannot be employed as a condiment, on account of its diſagreeable taſte. However it is uſed at table in the Northern countries, where it is ſaid to be conſumed in large quantities. Moſt of the products or the triple ſaline compounds, formed by the tartarous acidule, are alſo medicines more or leſs ſerviceable, and in uſe.

SPECIES II.

VARIETY II.

Of the Tartarous Acid.

A. *Hiſtory, Extraction.*

1. SCHEELE firſt taught chemiſts the means of extracting the tartarous acid from tartar, and ſeparating it from the portion of pot-aſh, which it contains in its ſtate of acidule. He communicated his proceſs to M. Retzius, who publiſhed it in the Memoirs of Stockholm for 1770. It is the firſt diſcovery that is known of this able Swede. Any given quantity of acidulous tartrite of pot-aſh is diſſolved in boiling water; carbonate of lime is thrown in till no more effervefcence takes place, and till the liquor no longer reddens the ſyrup of violets. The liquor is ſuffered to cool, and filtrated; in this manner inſoluble tartrite of lime is ſeparated in a white powder, which remains upon the filtre; it is then evaporated, and by evaporation nearly the half of the weight of the acidule employed is extracted in tartrite of pot-aſh, or vegetable ſalt. The tartrite of lime, being well waſhed, is put into a large glaſs cucurbit; a quantity of ſulphuric acid, equal to that of the chalk employed, and diluted with half its weight of water,

water, is poured upon it. This mixture is digested in a sand-bath for twelve hours, stirring it from time to time with a spatula of wood or glass. The sulphuric acid seizing the lime, forms a sulphate which is precipitated in the place of the insoluble tartrite, and the supernatant liquor contains the tartarous acid free. This is decanted, and after the precipitate has been well washed, and this lixivium mixed with the first liquid, it is tried by the acetite of lead, which forms in it a precipitate entirely soluble in vinegar, if the tartarous acid be pure, but not soluble, if it be mixed with sulphuric acid. In the latter case, it is digested again upon a little tartrite of lime, in order to take away the sulphuric acid that may be contained in it. It is then evaporated, and a little more than one third of the weight of the acidule employed is obtained in concrete tartarous acid.

2. It is probable that this acid exists pure in some vegetables, as Citizen Vauquelin has found about one sixty-fourth of it in the pulp of the tamarind; but it is so little abundant, and so much enveloped, as it appears, that we cannot yet hope to find means of obtaining it in a direct way, till it shall be ascertained that there exist plants, or parts of plants, in which it is contained in greater abundance than in those from which it has been extracted, or rather which have hitherto presented some traces of it.

3. Several

3. Several modern chemiſts have ſpoken of the converſion of ſome vegetable ſubſtances, and even of ſome vegetable acids into tartarous acid; but this has not yet been confirmed by experience; beſides which, they have yet prepared ſo little of it by this artificial proceſs, that it has not hitherto been poſſible to employ this method for obtaining the acid in queſtion.

4. It is to be obſerved, with reſpect to the proceſs of Scheele, the only one that has yet been practiſed for obtaining the tartarous acid free and pure, that lime may be employed inſtead of chalk; and that then all the tartarous acid being abſorbed by this earth, we obtain more of it on the one hand, and on the other there remains in the liquor which ſwims above the tartrite of lime only, pure and cauſtic potaſh. In order to obtain this acid ſufficiently pure, the firſt cryſtals are diſſolved again in diſtilled water, and this ſecond ſolution is evaporated to cryſtallization.

B. *Phyſical Properties.*

5. The tartarous acid extracted by the proceſs of Scheele has the form of cryſtals, moſt frequently in very fine needles, reſembling hairs. Bergman has repreſented them like leaves collected together at one of their extremities, and divergent at the other. Spielman and Corvinus have obtained cryſtals by cooling, grouped together in the form of plates, ſome in needles,

needles, others in pyramids. By a flow evaporation of the faturated folution, I have obtained it in irregular hexahedral prifms, but however fufficiently well pronounced. Slow and fpontaneous evaporation yields it in fquare plates a little rhomboidal with oblique edges.

6. It has a very acid and very pungent tafte, which ftrongly fets the teeth on edge, and which is not difagreeable, like that of the tartarous acidule. Diluted with water, it has a tafte refembling that of lemon-juice, and may be employed for preparing a good lemonade. It ftrongly reddens the blue vegetable colours, and is not fufible without alteration.

C. *Chemical Properties.*

7. WHEN expofed to the fire upon ignited coals, the tartarous acid is fufed, becomes black, emits fumes, fwells, exhales a pungent acid vapour, burns with a blue flame, and leaves a fpongy coal, in which are found fome traces of lime. When diftilled in a proper apparatus, it affords water charged with pyromucous acid, coloured oil, much carbonic acid and carbonated hidrogen gas; it leaves a voluminous fwelled coal, which yields no pot-afh, a certain proof that this alkali is not formed at the expence of the principles of the tartarous acid in the diftillation of the tartarous acidule, from the refults of which it differs only in the abfence of ammonia

monia in its products and of pot-aſh in its reſiduum. Spielman and Corvinus who have carefully diſtilled four ounces of this acid, concrete and cryſtallized in the pneumato-chemical apparatus, have obtained 431 cubic inches of carbonic acid gas, and 120 inches of carbonated hidrogen gas.

8. Amongſt the products of this decompoſition of the tartarous acid by fire, that which characterizes it the moſt, and belongs to it in a ſpecific manner, is the acid water which is obtained in the ſame manner as from the acidule. This is the pyrotartarous acid, the diſtinctive properties of which I ſhall here enumerate. The tartarous acid furniſhes more of it than the acidule; it amounts to at leaſt one-fourth of the weight of the firſt; it is a reddiſh liquor which is ſeparated from the oil by the funnel. It cannot be rectified by diſtillation without breaking the retort, by the kind of exploſion which it preſents, according to the academicians of Dijon. It has a ſlightly ſour taſte, and produces a diſagreeable impreſſion upon the tongue. It is ſtrongly empyreumatic; it reddens turnſole, but not the tincture of violets; it diſengages the carbonic acid from the earthy and alkaline carbonates with energy; it forms with the alkalis ſoluble and cryſtallizable ſalts. Its ſaline combinations are not well known, neither are thoſe which it is capable of affording with the oxides of the metals; it precipitates the nitric ſolution of ſilver in a white-grey powder;

that

that of mercury in a white powder, which is but flowly depofited; that of lead, likewife white. The attractions of the pyro-tartarous acid are not yet known; and the little that is hitherto known of its properties is merely fufficient to diftinguifh it from all the other acids, and to fhow that it is neither the nitric nor the muriatic acid, as was at firft imagined by fome chemifts. It is only evident that this acid is a fimple modification of the tartarous, that, like it and the other vegetable acids, it is compofed of carbon, hidrogen, and oxigen, and that it differs from it by the proportion of its principles, and efpecially by the larger quantity of hidrogen.

9. The tartarous acid is not altered by the action of the air; it is much more foluble in water than its acidule, as Bergman has made a folution of it, the weight of which was to that of water as 1230 to 1000. It is obtained feparate and cryftallized by the evaporation of its water of folution, whether this be effected by artificial means, or fuffered to take place fpontaneoufly. This folution is not altered nor decompofed fpontaneoufly except when it is diluted with water; when concentrated, it lofes nothing of its acid nature or of its properties.

10. Bergman believed that the tartarous acid was unalterable by the powerful mineral acids, and efpecially by the nitric acid; but Mr. Hermftaedt has effected its converfion into oxalic

oxalic acid, by diftilling it feveral times fucceffively with fix times its weight of nitric acid; 360 parts of tartarous acid afforded him 560 parts of cryftallized oxalic acid; which indicates the fixation of a large quantity of oxigen.

11. The tartarous acid forms with barites and lime infoluble, pulverulent, white falts, which are, however, diffolved by the aid of an excefs of their acid, and are decompofed by the mineral acids. Thefe two bafes have not only more attraction with the tartarous acid than all the others, but Bergman places magnefia before the alkalis in his table of elective attractions. The tartrite of lime ferves, as we have feen, for extracting the tartarous acid by means of the fulphuric acid.

12. The combination of the tartarous acid with magnefia and alumine yields no cryftallizable falts but gelatinous or gummy maffes. Citizen Vauquelin, by examining the fulphate of ftrontian found at Bouvron in the department of la Meurthe, and the combinations of the bafe which he has extracted from it, fays that the tartrite of ftrontian formed by the union of the muriate of this earth with the tartrite of potafh, is foluble, and cryftallizes by the heat of ebullition, that it contains 52,88 of ftrontian and 47,12 of acid.

13. When we unite tartarous acid with potafh, foda or ammonia, employing a proportion of the bafe lefs than is required for its fatura-

ſaturation, there is precipitated in the three combinations an inſoluble acidule, which each of the baſes has the property of forming. The differences which each of theſe acidules preſents have not yet been examined; and their analogy has only proved that the tartarous acid, in its ſemi-ſaturation by each alkali, becomes infinitely leſs ſoluble than the acid alone is, or its entirely ſaturated combination with any of theſe three alkalis. Theſe acidules all reſemble each other in being equally decompoſable by the powerful acids, all which have leſs attraction with the alkalis than the tartarous acid has with the firſt portion that unites with it.

14. The tartarous acid, combined with pot-aſh, and entirely ſaturated, forms a ſoluble ſalt, which was formerly termed *ſoluble tartar*, or *vegetable ſalt*, and which is deſignated in the new nomenclature by the name of *tartrite of pot-aſh*. We have ſeen above that the tartarous acidule, which is merely tartrite of pot-aſh with exceſs of acid, affords the ſame ſalt by the addition of pot-aſh: I have already indicated it, and have announced that I ſhould ſpeak of it in the hiſtory of the tartarous acid. I ſhall, therefore, here explain its principal properties. It is prepared by throwing tartarous acidule into a hot ſolution of carbonate of pot-aſh: a lively effervefcence takes place by the diſengagement of carbonic acid. Acidule is continued to be thrown in, till the liquor is ſaturated, and no longer

longer produces any effervefcence; it is boiled for the fpace of about half an hour; then filtrated, and afterwards evaporated to the formation of a pellicle, and fuffered to cool flowly; cryftals are formed in it in long fquares terminated by two oblique faces. This falt has a bitter tafte; it fufes, fwells and blackens upon ignited coals. It yields pyromucous acid, oil, and much gas by diftillation; it leaves a large quantity of alkali in its coal; it attracts in a fmall degree the humidity of the atmofphere; and is foluble in four parts of water at forty degrees. Its folution when kept for fome time is decompofed, depofits mucous flakes, and leaves oily carbonate of pot-afh in the water. Lime, barites, ftrontian, and probably magnefia decompofe it. The three firft bafes form in it an abundant precipitate. The mineral acids feparate from it the exceffive portion of pot-afh beyond the ftate of acidulous tartrite, and precipitate this acidule from its folution; heated with it for a long time and violently, they take from it the whole of the pot-afh by altering its acid: it decompofes moft of the metallic folutions. The tartarous acid, added to the folution of tartrite of pot-afh, changes it into tartarous acidule which is quickly depofited in fmall cryftals.

15. The faturated combination of tartarous acid and foda, or the pure tartrite of foda, is much lefs foluble than the falt of Seignette or the triple tartrite of pot-afh and foda; it cryftal-

 lizes

lizes in very fine needles or in thin plates, and not in large prifms of eight fides like the latter. Befides this is proved not to be the real falt of Seignette by the circumftance, that when a folution of tartrite of pot-afh is mixed with a folution of this pure tartrite of foda, provided that both have been concentrated without, however, cryftallizing, we immediately obtain cryftals of this falt of Seignette, or of tartrite of pot-afh and foda in prifms of eight fides, like thofe of this triple falt.

16. The ammoniacal tartrite, or the tartarous acid faturated with ammonia cryftallizes well. This bitter falt is very foluble and decompofable by fire, by barites, ftrontian, lime, magnefia, and the two fixed alkalis. The powerful acids precipitate from it an acidulous ammoniacal tartrite. Its folution is alfo fpontaneoufly decompofable with the aid of lime.

17. The tartarous acid decompofes all the alkaline falts, and takes from them the portion of pot-afh, of foda and of ammonia which it requires for forming acidules. It precipitates the nitrate, the muriate, and the acetite of lime from which it feparates this earthy bafe. It is evident that it is by no means fo weak as was formerly believed, fince it has more ftrength than the mineral acids.

18. There are but very few metals upon which it exerts an immediate action; but it unites with the moft of their oxides.

 A. The

A. The tartrites of arſenic, of tungſten, of molybdena, of chromium, of titanium, of uranium, of cobalt, and of nickel, are not yet known.

B. It forms with the oxide of manganeſe, from which it diſengages a portion of the oxigen, a limpid ſolution.

C. It does not act upon antimony, even with the aid of heat; it combines well with its oxides, eſpecially the vitreous ſulphuret or glaſs of antimony, and the powder of Algaroth; it forms a tartrite of antimony, which cryſtallizes but very little, very irregularly, and which yields, for the greater part, a gelatinous matter: whence it follows that this combination, ſo different from the antimoniated tartrite of pot-aſh, cannot be ſubſtituted in its place.

D. It has no effect upon biſmuth, but it takes its oxide from the nitric ſolution, and forms a tartrite of biſmuth precipitated in a white and inſoluble powder.

E. The tartarous acid, when triturated dry or liquid with mercury, favours its extinction, or its oxidation into the black ſtate. It unites with its red oxide which it whitens; it decompoſes and precipitates the nitrate of mercury, and forms, with its oxide, an inſoluble tartrite of mercury, which quickly becomes yellow by the contact of the air and of light. It acts neither upon the ſulphate nor the muriate of this metal.

F. It attacks zinc in an active and powerful

 manner.

manner, which prefents, by its contact a rapid effervefcence and difengagement of hidrogen gas. The tartrite of zinc which is formed has not yet been examined.

G. It has no direct action upon tin, or upon lead, though it appears to combine with their oxides. It whitens, by mere contact, the red oxide of lead. It decompofes and precipitates the nitrate and the muriate of the latter metal into a white infoluble tartrite.

H. It acts upon iron as upon zinc, diffolves it with effervefcence and difengagement of hidrogen gas, and affords a red folution which affumes the form of a gelatinous mafs without cryftallizing. Poured into the folution of fulphate of iron, it does not precipitate it; but when the mixture is heated, according to M. Retzius, it feizes the portion of oxide which detaches itfelf from this falt, and forms with it lamellated cryftals, little foluble, which, according to the fame chemift, are not precipitated by the pruffiates, unlefs acid of nitre is added.

I. Without fenfibly altering copper by its firft contact, it unites with its oxides and forms a falt of little folubility, of a green colour. Mr. Parker has obferved fmall, green, irregular cryftals formed at the bottom of the nitric and muriatic folutions of copper, into which he had poured tartarous acid, which had produced no fenfible effect at the firft moment when it was mixed with them.

K. It

K. It does not attack ſilver, or gold, or platina, nor does it precipitate the nitric ſolution of the firſt, or the nitro-muriate of the ſecond. However, the ſaturated ſalts effect theſe precipitations, like that of all the other metallic ſalts, by a double attraction.

L. In general all the metallic tartrites, moſt of which are pulverulent and little ſoluble, yield pyrotartarous acid by diſtillation, are decompoſed by the earths and the alkalis, form many triple tartrites, by the addition of a ſmall proportion of the latter, and always yield their oxides to the ſulphuric acid, ſometimes to the muriatic, rarely to the nitric. None of them have yet been employed.

19. The tartarous acid is one of the ſtrongeſt vegetable acids; it yields only to the oxalic acid. Compared with the other vegetable acids, it appears more eſpecially to differ from them by the proportions of its principles, and eſpecially by that of the carbon. Citizen Vauquelin and myſelf have found in our analyſes, that 100 parts of this acid contain 70,5 of oxigen, 19 of carbon, and 10,5 of hidrogen. Hence it appears to follow, that in order to convert it into oxalic acid, it is only requiſite to take from it 6 parts of carbon, and to add to it 6,5 of oxigen, without at all changing its proportion of hidrogen, which is the ſame as in the oxalic acid.

D. *Uſes.*

D. *Uses.*

20. Not much use has has yet been made of the pure tartarous acid, though known since 1770: it has hitherto been prepared, almost exclusively, in the laboratories of chemistry, in order to determine its properties and nature. It may, however, be employed as a cooling, antiseptic, and antifebrile drink; and, in the *War of Liberty*, a pretty considerable and very advantageous use was made of it in the military hospitals of the French Republic. Diluted with water, and sweetened with sugar or honey, it forms a very agreeable and wholesome kind of lemonade—a convincing proof that the faint and unpleasant taste of the tartarous acidule depends intirely upon its semi-saturation with pot-ash. As this acid may become so useful an object, it is essential to add an improvement, small indeed, but useful, to the art of refining the tartar, to that of preparing pharmaceutically its saline and medicinal combinations. It has been seen that there is separated, in these operations, at least 0,07 of cream of tartar, and consequently a much larger quantity of tartrite of lime in an insoluble powder, or a viscous paste of tartar, and that this matter has been well examined by Citizen Vauquelin. It will henceforth be advisable to collect it in the abovementioned operations, to wash it well, to treat it with the sulphuric acid diluted with water, and to extract from it the pure tartarous acid,

acid, which will be eaſily kept, and exhibited in the ſolid and cryſtalline form, or by giving it the nature of a ſyrup with the addition of ſugar, it may be ſubſtituted in place of the ſyrup of lemons.

SECTION IV.

Of the Third Genus of Vegetable Acids, or of the Empyreumatic Acids.

1. I HAVE already ſhown that a great number of vegetable ſubſtances, heated in cloſe veſſels, yield by diſtillation, acid liquors which did not exiſt in theſe ſubſtances previous to the action of the fire, and that this agent really produces them. It is not neceſſary here to return to the explanation of this phenomenon, or to repeat, that it is by a change amongſt the principles, and by a particular combination between the hidrogen, the carbon, and the oxigen, that this production of the empyreumatic acids takes place.

2. It is more eſſential to remark that theſe acids, though different from each other, have, nevertheleſs, ſome generic characters by which they approximate to each other. They derive theſe characteriſtic properties from the very nature of the phenomenon which has given riſe to them; they have all a burned taſte, a particular fetid acrimony, which chemiſts long termed *Empyreuma*. It is manifeſtly the ſame as that which diſtinguiſhes

diftinguifhes the oils produced by diftillation, which are alfo defignated by the expreffion of empyreumatic oils. We alfo fee that the fubftances that afford thefe acids are at the fame time fufceptible of yielding empyreumatic oil, and that the fubftances which yield no oil do not furnifh acids. It is in this manner that the citric acid, and efpecially the oxalic acid, which prefent no trace of oil in their diftillation, likewife prefent none of acid, whilft the tartarous acid, from which a very fenfible quantity of oil is extracted, yields at the fame time pyro-tartarous acid.

3. Hitherto only three empyreumatic acids are known; though it is very probable that feveral others will be found by examining well the products of a greater number of vegetables than has hitherto been done, efpecially when we reflect that chemifts, whofe attention has long been engaged by the property which vegetable fubftances poffefs of affording acid liquors by diftillation, have thought it one of the characters the moft proper for diftinguifhing thefe matters from the animal fubftances.

The three fpecies of empyreumatic acids hitherto known, are the *pyromucous*, the *pyrotartarous*, and the *pyroligneous*.*

* Though thefe acids are now known to be the acetous flightly altered by oil, I have not thought fit to omit the fubfequent fpecies. See appendix.

SPECIES

Species I.

Pyromucous Acid.

1. I HAVE already defcribed this acid in the hiftory of the mucous bodies and fugar to which it belongs, as a conftant product of the action which fire exerts upon them. I fhall here repeat nothing concerning its properties, except what may ferve to characterize it, by comparing it with the two others, and what belongs to its formation. Both thefe confiderations muft conduct us to a better knowledge of the nature of its products, and the characters by which they approach to, or are removed from the other genera of thefe compounds.

2. As to the origin, or the formation of the pyromucous acid, by collecting under the fame genus the different immediate materials of vegetables which afford this fpecies of acid by diftillation, or the action of fire in general, gum, the mucilages, the faccharine fubftances, and the amilaceous fecula, we fee that they have four very diftinct and very remarkable properties: the firft, that they are fweet, taftelefs or infipid; the fecond, that they form, with hot or cold water, gelatinous bodies; the third, that they contain and yield much coal in their analyfis; the fourth, that they are all converted into malic and oxalic acids, and fome of them at firft into mucous or fachlactic acid. It is

very

very evident, that thefe four properties agree well with that of affording pyromucous acid, that they depend upon the fame caufe, upon the fame primitive compofition, upon a very near relation between the proportions of their elements.

3. The pyromucous acid is characterized by its reddifh or brown colour, its pungent tafte, which, though empyreumatic in general, is different from that of the two other acid products of fire, its fmell equally diftinct and particular, its property of ftaining the fkin red, the falts which it forms with the different bafes, its attractions for thofe bafes, and the coaly mark which it always leaves upon the veffels in which it is heated. It cannot be doubted that it confifts of carbon and hidrogen combined with oxigen, though the proportions of thefe principles are yet unknown. It is known that by its laft decompofition it yields water, carbonic acid, and infulated coal.

SPECIES II.

Pyrotartarous Acid.

1. THE tartarous acidule, and the acid which is extracted from it, afford, as I have already mentioned, a particular acid by diftillation, and this acid has no more analogy with that from which it proceeds, than is found between the pyromu-

eous acid and the fubftances which furnifh it. I have indicated the characters of this empyreumatic acid; we have feen that its fmell, its tafte, and efpecially the falts which it forms with the earthy, alkaline, and metallic bafes, diftinguifh it from all others, and have induced chemifts, at all times, to acknowledge it as a particular product.

2. What is very remarkable in the production of this pyrotartarous acid, is that it is furnifhed only by the tartarous acid, and by the compounds into which it enters. The caufe of this phenomenon, by which the pyrotartarous acid alfo differs greatly from the pyromucous, will be found when the analyfis of thefe two acids fhall be made, and the proportion of the principles that enter into their compofition determined.

SPECIES III.

Pyroligneous Acid.

1. THE pyroligneous acid refembles the pyrotartarous acid in the circumftance that there is only one particular vegetable fubftance that furnifhes it by the action of the fire: this is the ligneous matter, or wood, as its name expreffes. I fhall not treat farther concerning this acid in this place, as its hiftory ought to be placed under that of the ligneous matter to which it belongs. I fhall only obferve, that the pyroligneous

ligneous acid, afforded by all diſtilled woods, is well characterized by its particular ſmell, its colouring property, and the ſalts which it forms with the earths and alkalis. The difference of this acid, from the two preceding, depends upon the primitive nature of the ligneous ſubſtance, which is very different from that of the mucilages and the tartarous acid.

Section V.

Of the Fourth Genus of Vegetable Acids; or of the Factitious Acids, which have not hitherto been found in Nature.

1. IN the ingenious method of treating the vegetable ſubſtances by the powerful acids, and eſpecially by the nitric acid, diſcovered in 1776, by the illuſtrious Bergman, theſe ſubſtances are converted into ſeveral acids, which did not previouſly exiſt, and I have ſhown that this converſion is owing to the change of the proportion of the principles, occaſioned by the oxigen of the acid, which ſeizes the vegetable ſubſtance. In this mode of action, which is explained by the pneumatic doctrine, there are two kinds of acid formed; the one are entirely ſimilar to the acids found in the vegetables; the others, on the contrary, are altogether different from thoſe which are found in the different ve-

 getable

getable ſubſtances, or at leaſt from thoſe that have hitherto been found, for we muſt not confound the limits of art with thoſe of nature. Theſe form the fourth genus which I diſtinguiſh.

2. It is not difficult to conceive, from what I have hitherto ſhown, that they derive their origin from a matter, or from ſome matters originally different from thoſe which afford the following; and in fact one of them, though it may proceed from ſeveral analogous matters, has however, in ſome meaſure, a ſtrict limit of formation; this is the mucous or ſachlactic acid; the two others are produced ſeverally by one of the particular matters, which are termed immediate materials of vegetables; the one with camphor, which on that account is termed camphoric acid; the other with the cork or the epidermis of the barks, which I term in general *ſuber;* and on account of this origin the acid is termed the *ſuberic acid.*

SPECIES I.

Mucous Acid.

1. I HAVE already given, in the hiſtory of gum, an account of the properties of the mucous, or ſachlactic acid: without returning again

again to what I have faid concerning it, I content myfelf with repeating that the infipid mucilages are the only fubftances that furnifh this acid, which was firft difcovered by Scheele, and which he for fome time thought to be peculiar to the fugar of milk; that the faccharine matter does not furnifh it by the action of the nitric acid, and that it is diftinguifhed from all the other artificial acids by its pulverulent ftate, its little folubility, its weak tafte, and by its faline compounds.

2. The exact proportion of its principles has not yet been afcertained, nor is it known how far it differs in this refpect from all the other vegetable acids. It may be fuppofed to contain a very large proportion of carbon, and that to the fuperabundance of this principle are to be afcribed its dry ftate, its infipidity, its infolubility, its inalterability, and all the other properties by which it is characterized.

It is, therefore, an acid hitherto too little known, and which deferves to be examined with great care, efpecially in its comparifon with the other fpecies of acids with binary radicals, with hidrogenated carbon, or carbonated hidrogen.

Species II.

Camphoric Acid.

1. THIS is never formed except at the expenſe of camphor; I refer its hiſtory to that of this ſubſtance; I ſhall here only obſerve, that being produced by a ſtrong and long continued action of nitric acid, it enjoys properties well characterized as a peculiar acid; that it approaches in its nature to the benzoic acid, with which it has even been confounded by ſeveral modern chemiſts; but that it would differ from it, had it no other diſtinctive property than that of not being ſeparated from its ſolution in alcohol by water, whilſt the benzoic acid is very eaſily ſeparated in this manner. Beſides which I ſhall hereafter ſhow it to poſſeſs many other characteriſtic properties.

Species III.

Suberic Acid.

1. THE ſame is the caſe with the ſuberic acid, the conſtant production of the action of the nitric acid upon cork: when once formed, it enjoys

enjoys properties which diftinguifh it from all other artificial acids. Its fmell, its decompofition by fire, its manner of feparating from a fatty fubftance at the moment when it is formed, are characters well pronounced, and well diftinctive of its fpecies, not to mention other individul properties belonging to it, of which I fhall treat hereafter.

Section VI.

Of the Fifth Genus of Vegetable Acids; or of the Artificial Acids refembling thofe of Nature.

1. I CANNOT dwell too much upon, or revert too often to the important difcovery of artificial acidification, and the approximation which exifts, if not between the proceffes, at leaft between the refults of the efforts of art, and of the operations of nature. It is extremely ftriking in the converfion of the not acid vegetable matters into acid fubftances, perfectly fimilar to thofe created by vegetation. This identity proves that the change that has taken place in thefe matters, at the time of their artificial tranfition into the ftate of acids, is the fame as that which they experience in nature.

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2. Three vegetable acids formed by the efforts of art have been diſcovered: beſides the oxalic acid, which was at firſt termed acid of ſugar, and found perfectly analogous to that of ſorrel, &c. the malic and the tartarous acids have been enumerated in this order. I ſhall here ſay a few words concerning each of theſe factitious acids, of which I have already ſpoken, or which I have deſcribed as native acids.

Species I.

Factitious Malic Acid.

1. SCHEELE was the firſt who aſſerted that he had converted the inſipid, or not acid vegetable ſubſtances into malic acid. He even found that all thoſe that yielded oxalic acid by the nitric acid, were at the ſame time capable of furniſhing malic acid. Mr. Hermſtaedt has ſince conſidered the factitious malic acid as a kind of preliminary to the oxalic acid, as on the one hand it is produced at the ſame time with it, and on the other capable of paſſing to the ſtate of oxalic acid.

2. Since the time of Scheele, it has been diſcovered that the oxigenated muriatic acid poſſeſſes the property of converting the inſipid vegetable ſubſtances into malic acid much more

more ſpeedily than is done by the nitric acid, that this converſion is more permanent, that it paſſes leſs eaſily into the ſtate of oxalic acid, than when it is produced by the action of the nitric acid. It is ſufficient to throw gum in the ſtate of powder into the liquid oxigenated muriatic acid, and to ſtir it therein for ſome time, in order to convert it into malic acid.

Species II.

1. THE opinion of the poſſibility of forming the tartarous acid artificially, reſts upon the authority of Meſſrs. Crell and Hermſtaedt. They have aſſerted that they have ſucceeded in effecting this decompoſition by means of the nitric acid; but no chemiſt has ſpoken of it ſince, or confirmed their firſt reſult. The poſſibility of the circumſtance, however, cannot be denied, unleſs we have exact experiments to oppoſe to their aſſertion; and there is nothing to oppoſe the poſſibility of this acid being formed by the efforts of art, as ſeveral others are formed.

SPECIES III.

Factitious Oxalic Acid.

1. OF all the acids that exist in nature, this is the most easily and most abundantly imitated or fabricated by art. Besides the mucus and the sugar, whose conversion into this acid by means of the nitric acid I have already indicated, we shall see hereafter, that a great number of vegetable and animal substances equally possess the property of furnishing it by the action of the same acid. I have already fully examined its properties, I shall here only add its most distinctive characters founded upon its crystallizability, its rapid decomposition into water and carbonic acid, its attraction for lime superior to that of all the other acids, and the insoluble salt which it forms with this base, whether it be combined with it in an immediate manner, or whether it takes it away from any other acid.

SECTION VII.

Of the Sixth Genus of Vegetable Acids; or of the Acids produced by Fermentation.

1. NOTHING is more common than to fee vegetable matters become fpontaneoufly acid, by a proper inteftine motion of their own fubftance. Befides the amylaceous fecula, the vinous liquors, &c. the ftalks, the leaves macerated in water, fpeedily affume the acid nature; and the roots undergo the fame alteration. Thefe are real fermented acids that are formed under thefe circumftances, and there has even been deduced from their formation a well-marked character of the vegetable fubftances, by calling them *acefcent*.

2. Notwithftanding the multiplicity of vegetable fubftances that become acid by fermentation; notwithftanding the very natural prefumption which leads us to believe that feveral different acids are formed by this inteftine motion, only two acids have yet been diftinguifhed amongft thefe products. And one of the two, the acetic acid, is merely a modification of the acetous.

SPECIES I.

Acetous Acid.

1. AS the properties of this acid will be explained in detail in the article concerning the acid fermentation, I ſhall content myſelf in this place with obſerving that this acid is not conſtantly the product of fermentation; that it is not always the effect of the ſourneſs of wine; but that it frequently proceeds from the alteration produced in vegetable ſubſtances by the ſulphuric or muriatic acid.

SPECIES II.

Acetic Acid.

1. THOUGH the acetic acid, the hiſtory of which will follow that of the preceding, is ranked here as a product of fermentation, it is merely a conſequence of acidification, and it ſucceeds the formation of the acetous acid; from which, as ſhall be ſhown hereafter, it differs only by a particular modification.

Article VIII.

Of the Fifth of the immediate Materials of Vegetables: of the Fecula.

A. *Situation.*

1. THE name of fecula is applied in chemiſtry to the dry, pulverulent and eſpecially white matter, which is precipitated from water in which ſeveral parenchymas of vegetables have been ſteeped. Though this name has alſo been given to the fibrous ſubſtances which impair the tranſparency of the expreſſed juices of plants, after the Latin word *fæx fæces (ordure)*, and though it is in conformity with this expreſſion that the juices are ſaid to be *defecated*, in order to deprive them in fact of their fecula, yet theſe remains of vegetable fibres, which belong to the ligneous matter, are at preſent no longer confounded with the fecula properly ſo called. On this account it has been propoſed to deſignate this by the expreſſion of *amylaceous fecula*, becauſe ſtarch is in fact the firſt and the moſt known of theſe ſubſtances.

2. The fecula properly ſo called, or the amylaceous fecula, is met with in different organs of vegetables; it exiſts in all the tuberous roots, ſuch as thoſe of the potatoe, of the orchis, of briony,

briony of manioc, &c. It is evident that the clafs of thefe feculent roots muft be extremely numerous and varied, and that in general we may recognize them by their brittle, feemingly granulated parenchyma, eafy to be bruifed, and reduced into a foft pafte under the finger, and prefenting in this pafte, when expofed to a ftrong light or to the rays of the fun, a brilliant, filky, or filver-like texture. We may alfo convince ourfelves of the exiftence of the fecula in roots, by the property which they have, when they have been bruifed, of giving to water in which they are agitated a milky opacity, as I fhall foon fhow more fully. Laftly, thefe roots, more or lefs charged with fecula, are alfo characterized by the property of becoming brittle, and more or lefs tranfparent, when they are dried, either by expofure to the rays of the fun, or by the heat of a moderately warmed ftove.

3. There are fome ftalks of plants, or rather trunks of trees, which contain a more or lefs confiderable quantity of fecula, fuch is efpecially the trunk of the palm tree, and undoubtedly of a much greater number of trees or plants which are not yet known, and which furnifh in fome climates an abundant nutriment to men and animals. There are as yet only fome fpecies of the palm, and efpecially the trunk of the *cycas circinnalis*, from which the nations of Afia known by the European travellers and philo-

philofophers derive a confiderable quantity of fecula, as I fhall fhow hereafter.

4. In the enumeration of the vegetable parts which afford fecula, I muft not omit obferving that none of it is extracted either from the leaves or the flowers, and that what is fometimes termed fecula, and is feparated from the juice of the firft of thefe organs, is only a detached portion of the fibrous texture or of the ligneous fubftance which impaired its tranfparency; accordingly, as I have already indicated, this fibrous fecula ought not to be confounded with the real amylaceous fecula; and nothing is more proper for well fixing their difference than the propofition that neither the leaves properly fo called, nor the flowers, contain any of the latter.

5. Some fruits, and efpecially all thofe that are flefhy, parenchymatous, brittle, fufceptible of being dried or baked, and foftened by hot water into a kind of femi-tranfparent jelly, contain a more or lefs confiderable quantity of real fecula, though chemifts have hitherto fcarcely remarked it, becaufe they knew that it is not extracted from them, and that it cannot be prepared and employed like the other fecula. And in fact, thefe fruits are at the fame time more or lefs pulpy, faccharine, mucous, and mixed with fo large a quantity of infipid or faccharine mucilage, with which the fecula intimately adheres, that it would be difficult to extract it from thefe mixtures for economical

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ufes: but it is, neverthelefs true, that when thefe foluble and vifcous fubftances have been extracted by chemical operations, by accurate preffure and wafhing, there remains a white matter, in a brittle pafte, ftill mixed with fibrous and ligneous matter, but which contains amylaceous fecula, more harfh and crude indeed than that which is furnifhed by the other parts of plants.

6. The feeds or the grains feem to be the vegetable organs in which nature has depofited the largeft quantity of amylaceous fecula; and as it is in thefe fubftances that animals find the moft abundant nutriment, we alfo find by obfervation that this matter is deftined by nature to ferve as aliment to the vegetable embryo. There are even fome feeds, efpecially thofe of the gramineous plants, which feem to be entirely formed of this feculent matter: accordingly, it is from this kind of parts that the moft pure and the moft abundant ftarch is extracted. In many other grains the amylaceous fecula is mixed with colouring parts, extracts, mucilage, or oil. In this confifts the chemical difference which exifts between the different kinds of feeds.

7. Laftly, there are fome fpecies of vegetables, the whole of which and all their parts appear to be tiffues of feculent matter, or to contain fuch an abundance of it that they ferve entirely to form real farina. Such the genus of lichen appears efpecially to be, amongft the

fpecies

ſpecies of which are particularly diſtinguiſhed the *Lichen Iſlandicus*, of which a kind of bread is formed in Iceland, and the *lichen rangiferinus*, which ſo eaſily nouriſhes the rein-deer. Such appear to be alſo ſeveral ſpecies of ferns, the ſtalk or the roots of which furniſh the inhabitants of ſeveral of the South-Sea iſlands with a food which much reſembles our farinaceous aliments, and is converted, by baking, into a kind of cake or agreeable paſte, ſimilar to our bread prepared from grain.

B. *Extraction.*

8. THE amylaceous fecula is extracted by ſimply pounding the vegetable parts that contain it, and agitating theſe pounded parts in water. The fecula is often found to be mixed with two kinds of ſubſtances: the one ſoluble in water, which remains diſſolved in the ſupernatant liquor; and the others, not being ſoluble in this liquid, are parenchymatous, fibrous and woody. The latter, which are much heavier and much groſſer than the fecula, are firſt depoſited in flakes, and leave the ſtarch ſuſpended, in a very fine and very light white powder in the water, which is then turbid like milk.

9. In order to ſeparate this parenchymatous, groſs and heavy matter from the pulverulent fecula, which is capable of being ſuſpended for a very conſiderable time in water, a very ſimple and commodious means is employed. After having

having rafped the feculent root, the flaky pulp which proceeds from it is put upon a rather clofe hair-fieve; water is poured upon this pulp, which is worked with the hand, and rubbed with a rounded fpatula. The water, interpofing itfelf between the particles of this parenchymatous pulp, and being every where in contact with it, detaches from it the fecula with which it is enveloped, and carries it along with it through the mefhes of the fieve. This wafhing and agitation is continued till the water runs off without opacity, that is to fay, till it has carried away all the fecula: there then remains upon the filtre a parenchymatous grey or femi-tranfparent portion. The water which paffes through the fieve falls into the veffel, in which it is received turbid and white like milk; it depofits in the courfe of time all the fecula which it contains, in a white layer which occupies the lower part of the veffel, and diminifhes in thicknefs in proportion as its particles approach each other, but remains thick and like a very fine pafte, on account of the water which it retains between its particles. The water that has become clear at its furface is poured off; the fecula is dried after it has been cut into fragments, which are fpread upon pieces of blotting paper; when it is fufficiently dry to be eafily divided by the preffure of the finger into a fine and foft powder, it is properly prepared.

10. This operation is moft frequently performed in the large way for the purpofes of life,

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and then it is practiſed in raſping mills moved by handles, or even by water: in this manner the potatoe is treated. As to the farinaceous grains which are almoſt entirely compoſed of amylaceous fecula, it is almoſt always thought ſufficient to bruiſe them under mill-ſtones moved by the wind, water, or fire-engines. This ground corn yields the farina, and is ſeparated more or leſs eaſily from the bran or the ſkins bruiſed by the mill-ſtone, according to the kind of grain which is employed. However this farina is not conſidered as pure fecula; it is neceſſary to waſh it with water, and ſuffer it to depoſit the ſtarch which this fluid dilutes and carries with it, in order to ſeparate it from the portion of ſoluble and inſoluble matters which it contains, and of which I ſhall ſpeak hereafter.

11. It is eaſy to ſee, that according to the greater or leſs purity of the fecula, or according to its natural mixture with different ſubſtances, ſuch as the mucilages, the ſaccharine bodies, the extracts or the colouring parts which it contains, it requires to be treated by a more or leſs careful or repeated waſhing; the water diſſolves theſe foreign ſubſtances and thus retains them, ſuffering the fecula to be precipitated. By evaporating the liquid, by means of fire, we collect theſe ſoluble ſubſtances, diſcover their nature, and determine their quantity. In the proceſs of the purification of the fecula, the waſhing is continued

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till the water employed has neither colour nor ſmell. There is no feculent vegetable matter, however acrid, however bitter, however coloured it may be, which will not by this means yield pure and white fecula. In this manner ſtarch is extracted in conſiderable purity from all the farinas of leguminous ſeeds, yellow, green, or fawn-coloured, and even from the acorn and the horſe-cheſtnut, which however are of all the ſeeds thoſe which contain the moſt matter foreign to this vegetable principle, and of an acrid, acerb, bitter, or diſagreeable taſte. There are a great number of ſubſtances which, if treated in this manner, might become uſeful, but which have not hitherto been employed for this purpoſe.

12. When the fecula is accompanied with oily ſubſtance, which is eſpecially the caſe in the grains of the cruciferous plants, in the ſeeds of the ſyngeneſian compounds or plants, in the kernels of ſtone-fruit, in the ſeeds of the cucurbitaceous plants, &c. we begin, in order to extract it, with the expreſſion of the oil, as ſhall be ſhown in the hiſtory of this laſt ſubſtance. When the oil has been ſeparated, the paſte or the cake which comes out of the preſs is waſhed with water, as the pulps of the roots the ſtalks, the farinæ of the gramineous plants are treated; and in fact, when once exhauſted of oil, the parenchyma of the ſeeds, which are in general called *emulſive*, ſuffers its fecula to precipitate from the water; whereas, previous

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to the extraction of the oily substance, it remains suspended with the oil in the state of emulsion; however there is a part which is attached to the parenchymatous portion of these seeds that does not enter into the emulsive liquor.

13. The advantageous effects of the employment of water in the separation and purification of the fecula will be still better conceived, when it is remarked, that we may thus even obtain it pure, wholesome, mild, and alimentary, from the midst of the most acrid and poisonous pulps, without its retaining any thing of the deleterious property of the pernicious juice, or extract which accompanies it. In the distinction of the species I shall especially apply this remark to the fecula of briony, that of the manioc, &c.

C. *Physical Properties.*

14. The fecula thus extracted, prepared and purified, is a white powder of a faint taste, or almost without any, very little or very slightly pasty in the mouth, more or less adhesive to the tongue and palate, light and soft under the finger, dividing itself very easily, attaching itself sensibly to the skin, to which it adheres when applied to it rather strongly.

15. When viewed with attention, especially while the rays of the sun fall upon it, or with a good magnifying glass, we perceive

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it to be formed of ſmall tranſparent globules, brilliant, ſilvery, ſilky in their maſs, and reſembling a kind of cryſtalline matter: when compreſſed with force, it emits a ſlight ſound, a peculiar kind of crackling, which every one muſt have obſerved in fine and well prepared powder.

16. It floats upon water, appearing at firſt not to become moiſtened, and is penetrated by that liquid but very ſlowly; it even poſſeſſes when thrown upon this liquid, a kind of oſcillatory or rotatory motion, which continues a long time, and does not ceaſe till oil is applied to the ſurface of the water, or till it is entirely impregnated with this liquid.

D. *Chemical Properties.*

17. It muſt firſt be obſerved, in order to underſtand the chemical properties of pure fecula, that, from whatever vegetable matters it is extracted, whatever coloured or ſapid admixture it had at firſt, it is always the ſame with reſpect to its intimate nature, and that it is an abſolutely identical body, to whatſoever plant it may have belonged. It preſents only ſome differences of whiteneſs, fineneſs, apparent texture, or lightneſs; but its intimate qualities or its nature preſent none.

18. Well purified ſtarch, which I ſhall take as an example of the genus, when expoſed to the fire and air, upon an ignited coal, becomes coloured, paſſes

paſſes through the ſhades of yellow, orange, red, and brown, before it becomes black; is ſoftened, ſwells, exhales a pungent white fume, of a not diſagreeable acid ſmell, analogous to that of mucus and of ſugar. The coal which is thus formed is a little more voluminous than the ſubſtance itſelf was, though ſenſibly leſs ſo than that of gum. When diſtilled with a pneumato-chemical apparatus, water is obtained charged with pyromucous acid, ſome drops of red or brown oil, much carbonic acid, and carbonated hidrogen gas. This laſt burns with a light blue flame, and in a rapid manner; its flame, when it is kindled in a narrow and long bell-glaſs, deſcends horizontally in the veſſel; there remains a coal of a ſingle piece, a little ſpongy, eaſy to be burned, which leaves only ſome traces of pot-aſh and of lime; the latter is united with phoſphoric acid. This analyſis reſembles that of the mucus.

19. Starch does not appear to experience any conſiderable alteration by expoſure to the air; through it attracts moiſture; it collapſes and becomes in the courſe of time fatty and viſcous, as it were, and contracts a ſour taſte, with a ſmell as if rancid; but it requires a great length of time before this effect is produced. There is no mutual action between ſtarch and the ſimple combuſtible bodies.

20. It may be diluted in pure and cold water, by motion and agitation; and forms with it a kind of paſte without coheſion, and not ductile, which

which dries and cracks in the air. When a larger quantity of liquid is added, the ſtarch remains for ſome time ſuſpended in it, and appears like a kind of thick milk. If we ſuffer it to remain in this ſtate with the water at a temperature that exceeds fifteen degrees of Reaumer, it ferments, riſes, becomes a little heated, and turns ſour. Theſe phenomena take place in a much more ſpeedy and powerful manner, when it contains ſome foreign principles, ſuch as the gluten, or an extractive and colouring matter: thus the farina of corn ferments, and becomes ſpontaneouſly ſour in the proceſs of ſtarch-making; but in this work itſelf, the portion of ſtarch which eſcapes aceſceney, is ſeparated more pure and white from the different foreign matters that were united with it. It is believed that the acid which is formed in this caſe, and which exiſts in ſo marked a manner in the ſour water of the ſtarch-makers, is acetous acid; though I do not know that it has been ſubmitted to a particular examination.

21. Boiling water acts upon ſtarch in a very different manner. At this temperature, the whole of the fecula is diſſolved in the liquid; it forms a kind of gelatinous tranſparent ſubſtance. On this account the product of this operation is termed potatoe-jelly, when it is made with the fecula extracted from that root. This property is the diſtinctive character of pure fecula. There is no fecula, from whatever vegetable matter it may have been taken, which

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does not prefent it in a more or lefs marked manner, and which is not eafily recognizable by the gelatinous and tranfparent confiftence which it affumes by this operation. It then becomes very fimilar to a mucilage, and appears to pafs into the mucous ftate. In fact, if we expofe to a gentle and fufficiently continued heat, this fpecies of vegetable jelly, it thickens, dries, becomes brittle, retaining a femi-tranfparency, and greatly refembles a gum, all the products of which it affords. In this ftate it is very difficult to diftinguifh it from the mucous fubftance, and it deviates from it only by very flight differences: accordingly, moft chemifts have been led to confider the fecula as a kind of mucilage condenfed, become dry and pulverulent, and infoluble in cold water, by the progrefs of vegetation itfelf, fufceptible of repaffing into its former ftate by the combined action of caloric and of water. This opinion becomes very probable when we obferve that the vegetable fubftances moft fufceptible of becoming charged or filled with ftarch, prefent, previous to its formation, a kind of tranfparent jelly, which becomes white like milk, afterwards thickens, condenfes, and dries in proportion as its maturity advances. The accuracy of this obfervation is known in all the cereal grains, and in the emulfive feeds, which pafs through the fucceffive ftates of jelly, of thick milk, and of a kind of mucilage, tranfparent, and afterwards opaque,

opaque, before they aſſume the ſolidity which ought to characterize them.

22. In this gelatinous or mucous ſtate, which the fecula aſſumes by means of boiling water, it has the faint taſte or inſipidity of the mucilages, the property of being thickened by the action of the fire, or being diluted and diſſolved in water, and of turning ſour in the courſe of time. It particularly acquires the property of being eaſily digeſted, and ſerving for the nouriſhment of man, with much greater promptitude than it could in its dry, pulverulent, and inſoluble form. Accordingly this kind of boiling or ſolution in hot water, which is manifeſted and marked by a particular ſmell which is ſufficiently agreeable, is the moſt general, and, in ſome meaſure, the moſt conſtant preparation which men employ for converting the fecula into a more pleaſant and lighter nutriment, which very quickly recruits their ſtrength, and is ſpeedily converted into their own ſubſtance. It is eſpecially under this form that it is given to children, with whom it is ſometimes ſubſtituted inſtead of the milk of their mothers, or ſupplies its place pretty conſtantly, as we ſee amongſt moſt civilized nations.

23. The acids with ſimple radicals, alter the amylaceous fecula more or leſs powerfully, and comport themſelves with it preciſely in the ſame manner as with mucus. When diluted with water they diſſolve it, eſpecially with the aid of heat, much more quickly and eaſily than water

 alone

alone does; they form with it a kind of jelly or mucilage of a perfect tranſparency: when they are concentrated they decompoſe it. The ſulphuric acid blackens it, forms water and acetous acid by the union of its principles, which it ſolicits in another order than that in which they were combined, and precipitates carbon from it. With the aſſiſtance of fire it diſengages carbonated hidrogen gas from it, as it does from gum or ſugar. The muriatic acid acts in the ſame manner upon ſtarch, but much more ſlowly than the preceding acid. The nitric acid diſſolves it by heat without reducing it to coal, diſengages nitrous and carbonic acid gas, does not precipitate mucous acid from it, as it does from the gums, but converts the whole amylaceous maſs into malic and oxalic acids. The carbonic acid renders the fecula more ſoluble, and promotes its aceſcency.

24. The cauſtic or pure alkalis, diſſolve fecula with the help of water, reduce it to a gelatinous ſtate, but do not alter its intimate nature except with difficulty and at a high temperature. The ſalts which quickly part with oxigen, burn and decompoſe it. Thus it is deſtroyed by nitrate of pot-aſh when heated with it. It inflames and detonates violently by mere preſſure or percuſſion, with the ſuper-oxigenated muriate of pot-aſh, which inflames it.

25. The metallic oxides alſo burn it, eſpecially thoſe that are little tenacious of their oxigen; the ſame is the caſe with the metallic

ſolutions

ſolutions, from which it frequently ſeparates the oxides by mere contact, continued for a longer or ſhorter ſpace of time, colouring them, as they uſually are, according to the different proportions of oxigen which they yield to it.

26. Fecula unites eaſily in nature, and even by the operations of art, with moſt of the different immediate materials of vegetables; thus it is found aſſociated in plants with the extracts, the mucus, the ſugar, the oils, the colouring matters, and the gluten. Art alſo effects theſe factitious aſſociations pretty eaſily, eſpecially that with the colouring ſubſtances; by this means, as I ſhall ſhow elſewhere, are fabricated the colours ſo much uſed for paper, and ſometimes even for valuable paintings, which are known by the name of lakes.

27. From all the chemical properties which I have juſt preſented relative to the amylaceous fecula, it may be concluded that this body is a kind of dry and pulverulent mucus, different however from the gummy matter in its affording no mucus acid by the action of the nitric acid, and its not being ſoluble in cold, but only in boiling water. It announces itſelf as being a little leſs carbonated than the latter, though I cannot yet preſent the proportion of the principles that enter into its compoſition. It might be ſaid to follow the ſaccharine matter very nearly, and we ſhall ſee hereafter that it appears to be actually capable of forming it by a peculiar alteration of its own ſubſtance. As ſome chemiſts have announced that the fecula

affords

affords fenfible traces of ammonia in its analyfis, it fhould feem, from this circumftance, that the fecula contains azote amongft its primitive principles. However this affertion relative to the production of ammonia in the analyfis of ftarch by fire wants confirmation, and cannot yet be admitted as a demonftrated fact.

E. *Species of Feculas.*

28. Though there is only a fingle fubftance that ought to bear the name of fecula or ftarch; though this fubftance is exactly of the fame nature in all vegetables, when it has been extracted and purified with eafe by chemical proceffes, it is a matter of too great importance to fociety to be well acquainted with the principal ftates in which it exifts in nature, as is alfo the art, which is founded upon this knowledge, of applying it to the different ufes to which it may be made fubfervient, for us to omit paying fome attention to the fpecies of it which nature prefents. It is very evident at firft that the diftinction of thefe fpecies can be founded, and their real difference eftablifhed, only upon the different mixtures which it prefents in the vegetables that furnifh it, as well as upon the diverfity itfelf of the parts from which it is extracted.

29. Under the firft relation, that is to fay, under that of the different mixtures, or combinations which diftinguifh the amylaceous fecula in vegetables that contain it, we may admit

admit fix principal ftates, or fix fpecies of fecula, according to the nature of thefe different fubftances which are mixed with it. I fhall firft obferve, that it is no where abfolutely or intirely pure and infulated, that wherever it is met with, it is alloyed with fome foreign fubftances, and that on this account we are obliged to feparate it by water, which takes it up in powder and depofits it, retaining the foluble matters, and leaving feparate the grofs parenchymas which likewife altered it. The fix principal fpecies which I diftinguifh, by adding to their names adjectives which characterize each foreign matter, are the *glutinous fecula*, the *extractive fecula*, the *mucous fecula*, the *faccharine fecula*, the *oily fecula*, and the *acrid fecula*.

A. The *glutinous* fecula is that which is found naturally united with glutinous matter; it is found in wheat, and, in general, in all the cereal grains, though moft of them contain much lefs gluten than the firft. We fhall fee in the fubfequent article by what procefs the feparation of the gluten, which gives it particular properties, is effected.

B. The *extractive* fecula always recognizable by its fawn, yellow, greenifh, &c. colour, is efpecially found in the leguminous feeds, and in the farina which is obtained from them by grinding. It is to an extract that it owes its colour and its harfh, acerb, herbaceous, bitter tafte, as well as its more or lefs pungent fmell. The farina of peas, lentiles, French beans, lupines,

pines, chich-peas, &c. is of this ſpecies. There are alſo found varieties more inſupportable and more difficult to be purified in the horſe-cheſtnut, the acorn, &c. It is very difficult to extract it pure, which requires long and abundant waſhings.

C. The *mucus* fecula, well characterized by its viſcous gluey ſtate, exiſts in many roots, in all the unripe kernels, in the cereal grains in the milky ſtate. Sometimes it is only the tranſition from the mucous to the feculent ſtate; ſometimes it remains in the gluey and mucous form at all the periods of vegetation. The root of the potatoe, *convolvulus patatas*, is the moſt marked and ſtriking example of it. This fecula is very difficult to be obtained pure.

D. The *ſaccharine* fecula, or the natural mixture of fecula and ſugar, is found in ſeveral roots, in ſome ſaps, and even in the gramineous ſeeds when they have germinated. It is one of the moſt uſeful aſſociations which nature can preſent to man, and it is the ſubſtance which he ſeeks with moſt avidity for his nouriſhment. Both food and condiment are united in this natural combination. The ſugar is very eaſy to be ſeparated from the fecula, on account of its great ſolubility in water; and the moſt ſimple waſhing is ſufficient for this operation.

E. The *oily* fecula is very frequent in a great number of emulſive ſeeds, or thoſe which by being bruiſed, together with water form a milky liquid. When the oil has been ſeparated by expreſſion,

preſſion, the fecula which remains, beſides that it obſtinately retains a ſmall quantity of it, as is perceived by the unctuoſity of the paſte of kernels, is alſo mixed or charged with a mucous and extractive matter, and even with ſome ligneous particles which cannot be ſeparated from it except by ſeveral ſucceſſive waſhings and depoſitions.

F. The *acrid* fecula, whether it be pungent, like that of the cruciferous and antiſcorbutic roots, or cauſtic and burning, like thoſe of arum, of aſſarabacca, of briony, &c. or poiſonous, like that of manioc, owes this property to a portion of the juice of the plant itſelf that remains upon its ſurface, and which, when it is dried, without having been previouſly waſhed in a large quantity of water, preſerves in it a part of the properties, whether alterative, purgative, or even poiſonous, which the intire juice itſelf poſſeſſes. We may deprive it of this taſte, and render it very mild and ſimply nutritious, by merely waſhing it with pure water, in ſufficient abundance not to leave any foreign parts.

30. It muſt be added to this enunciation of the ſix ſpecies of fecula, diſtinguiſhed by the foreign matters that are mixed or combined with it by nature, that the fecula is often found aſſociated at the ſame time with ſeveral of theſe matters, which I have only indicated ſeparately in order to preſent the mixtures in an orderly arrangement. Thus the fecula of the

the leguminous plants, or the farina of peafe, beans, &c. frequently contains one or two extracts, a colouring fubftance, and a mucous matter. The pafte of kernels of different kinds, befides the oil, contains, as I have announced, colouring matter, extract, mucilage, ligneous matter, and fometimes even faccharine fubftance. It is moreover evident, that thefe multiplied combinations may greatly vary, according to the different ftates of modification of the trees or plants which furnifh them.

31. Another diftinction, no lefs important to be made between the feculas, is that which relates to the vegetable parts from which they are extracted. It is to this diftinction that the feries of the fpecies of fecula which are prepared for the purpofes of fociety really appertains. Amongft the feculent and acrid roots are reckoned thofe of briony, of arum, of manioc, of potatoes, and of orchis; amongft the ftalks, thofe of the palm, which furnifhes fago; amongft the feeds of the graminaceous plants, meal, properly fo called; amongft the clafs of vegetables which feem to be intirely compofed of it, the nutritive pafte of the Lichen Iflandicus; finally, we may alfo enumerate amongft thefe fpecies the pafte of paper. I muft fay a few words concerning each of thefe feculas in particular, and even add fome details concerning thofe vegetables, which, though none has hitherto been extracted from them, may afford very ufeful feculas.

A. The

A. The fecula of briony formerly was prepared for pharmaceutical ufes. After this root had been peeled, rafped, and preffed, it was fubmitted to the prefs, by which means a turbid and milky juice was extracted, which was filtrated; the fecula which it had precipitated upon the filtre, was wafhed, and the mafs which had remained in the prefs, was diluted with water: this laft wafhing afforded a fecula more abundant and ftill finer than that which was depofited by the expreffed juice. Thefe two feculas, mixed and wafhed for the laft time with a fufficient quantity of water for it to pafs off without tafte, were very pure, very taftelefs, infipid, or mild; no longer partaking of the acrimony of the root, they may be ufed like the ftarch of wheat, from which they differ in no refpect. When it was defired to have it purgative, it was not wafhed and precipitated by means of water; but the expreffed juice was fuffered to form its depofit without the addition of water. When well wafhed, on the contrary, it may be employed as food.

B. The root of the arum, that of affarum, and many other acrid tuberous roots of our climates, might be treated like thofe of briony, and furnifh, like this, a white fecula, fine and pure, mild and alimentary, when well wafhed; but acrid, purgative, and emetic, in a degree the more intenfe, the larger the quantity of the juice of the plant that fhould be left in it.

C. The

C. The root of the manioc, *jatropha manioc* of Linnæus, confiſting of ſeveral large, fleſhy, and ovoid tubercles, is employed chiefly in America as food for man, though, like the preceding, it contains a very acrid and intenſely poiſonous juice, ſince, according to all the hiſtorians of that country, a ſpoonful is ſufficient to poiſon a man. After the freſh root has been peeled, it is incloſed in a ſack of ruſhes of a very looſe texture, which is ſuſpended to a ſtick placed upon two wooden forks; to the bottom of this ſack a heavy veſſel is ſuſpended, which, by drawing the ſack, preſſes the raſped root, and receives the juice that flows out of it. When the fecula is well exhauſted of its juice, it is expoſed to ſmoke in order to dry it, and when it is well dried it is paſſed through a ſieve. In this ſtate it is termed *caſſava*; this is a kind of farina. It is baked into cakes, by ſpreading it upon hot plates of iron or earth, and turning it upon both ſides in order to give it a gold or reddiſh colour. It is alſo formed into *couac*, or ſmall grains, reſembling ſago, by agitating it for ſeveral hours in a baſin placed over the fire. The expreſſed juice of the manioc depoſits a fecula finer than the preceding; after it has been well waſhed and dried, it is employed for making confectionary; it is termed mouſſache. We ſee here the ſame reſults as are obtained with the roots of briony, of arum, and of aſſarum.

D. The

D. The root of the *ſolanum tuberoſum*, or potatoe, has for ſeveral years paſt been employed for preparing a very fine fecula, a very fine, very white, and very mild ſtarch, which has been called *amidon de ſanté*, on account of its good properties. After theſe roots have been peeled, they are raſped, and the pulp is placed upon a cloſe hair-ſieve; water is poured upon this pulp and agitated with it, till the liquid no longer carries along with it any white matter. The liquid which paſſes off depoſits a very fine and very mild white powder, which is carefully dried, and becomes brilliant and as it were cryſtalline by this deſiccation. It preſents all the properties of pure ſtarch, which it even ſurpaſſes in fineneſs and whiteneſs, when it is well prepared. A kind of ſago is made of it, by drying it whilſt moiſt and conſtantly agitating it in a veſſel over a gentle fire. The water which ſwims above this fecula has frequently a greeniſh aſpect, which depends upon the extractive part which it has taken from the root. Raſping-mills have been contrived for preparing a large quantity of the fecula of potatoes at a time. It is alſo formed into a kind of vermicelli, by paſſing it moiſtened with a little water through a cylinder perforated with holes at its extremity, and drying the ſoft ſmall cylinders that are formed by this kind of mould.

E. Salep, which is alſo called *ſalab*, *ſalop*, &c. in different parts of the Eaſt, is formed from the

the roots of different ſpecies of the orchis, eſpecially the *orchis moria*, which are dried in the ſun, either after they have been boiled in water, or, which is the more frequent practice, after they have been merely cleaned and well rubbed with bruſhes in this liquid. In the latter proceſs, which is greatly preferable to the firſt, the bulbs when well bruſhed are dried in a ſtove which renders them brittle, dry and ſemi-tranſparent. The roots dried in the ſun are ſtrung in a row upon ſtrings, by means of which they are ſuſpended in the air. This ſimple preparation enables them to be eaſily reduced into powder or ground, ſo that they may afterwards be boiled in water. The ſalep thus forms a kind of very mild and very nouriſhing jelly, the analeptic and mollifying power of which was formerly much extolled. The ſame operation may be performed, and an equally wholeſome and uſeful food prepared with the more or leſs tuberous roots of all the ſpecies of orchis.

F. Sago is a dry fecula, in round and ſlightly reddiſh grains, baked or condenſed by the action of the fire, which is brought from the Moluccas, eſpecially from Java, and from the Philippine iſlands. It is extracted from a ſpecies of the palm, termed *landan* in the Moluccas, which is the *cycas circinnalis* of Linnæus. The trunk of this tree contains a white and ſweet pith, which the inhabitants extract by ſplitting the tree longitudinally. They bruiſe this pith, put it into a kind of funnel of bark, placed over a hair ſieve, and ſoak it with a large quantity of water;

the

the fecula carried away by the liquid paſſes through the holes of the ſieve, and leaves upon it the fibrous and groſs part of the pith. The water, received into a pot, depoſits in it a light fecula, which is detached from the medullary texture; when the depoſition has been well performed, they pour off the water; and paſs the former through perforated plates, which give it the form of ſpherical grains; theſe they afterwards dry over the fire in veſſels in which they conſtantly agitate it. Theſe grains of ſago ſwell, ſoften and become tranſparent when boiled in water.

G. Farina, or flour, properly ſo called, that which is obtained from wheat, and differs conſiderably from that of all the other kinds of gramineous plants, is a dry, friable ſubſtance, little ſapid, though ſoft under the finger and upon the tongue, is prepared by merely pounding or grinding the grains of wheat. Though the farina of rye, of barley, of oats, of maize, and of rice, reſemble it, in ſome reſpects, yet the flour of wheat, *triticum*, a ſpecies of plant, which civilized man has ſelected amongſt thouſands of others as the beſt adapted for his nouriſhment, a vegetable which cultivation has maniſeſtly improved and modified for our wants, differs, however, from them in its property of forming with water a paſte conſiderably ductile and homogeneous, which eaſily retains the forms which we give it, which riſes and becomes divided by a commencement of fermentation, and alone affords good bread, and forms this aliment, ſo general, ſo uſeful, and ſo well known by almoſt

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all mankind as their firſt nouriſhment. Theſe properties are owing to the mixture of the three ſubſtances which conſtitute it; the amylaceous fecula properly ſo called, which forms nearly three fifths of it, and is extracted from it by waſhing the paſte, which the water carries away and depoſits in a white powder; the glutinous matter, which remains in a viſcous and elaſtic maſs after this waſhing, and of which I ſhall ſpeak in the ſubſequent article, conſtitutes nearly a fifth of the whole weight of the farina; and a ſaccharine matter which remains diſſolved in the water, and is obtained from it by evaporation. It is known that it is more eſpecially from this farina that ſtarch properly ſo called is extracted. It is alſo known that the farina of wheat muſt admit of varieties in the proportion of its three principles, according to a multitude of circumſtances of vegetation. It is alſo proper here to remark that bread which is well made, and which has fermented into leaven, is acid, that its decoction reddens the blue vegetable colours, and that it becomes ſtill more ſo in the ſtomach.

H. Several ſpecies of lichens, but eſpecially that which grows in ſuch abundance in Iceland, and which on that account is termed *Lichen Iſlandicus* by Linnæus, is employed for making a very nouriſhing kind of bread in the Northern countries. From the experiments made by the Academy of Stockholm upon this lichen, it appears that it affords by ſimple grinding an excel-

excellent ſtarch. The ſame alſo appears to be the caſe with the *lichen rangiferinus*, on which the rein-deer are ſupported, and which ſo eaſily fattens them. The inhabitants of Iceland prepare from the farina of their lichens a very delicate and much eſteemed meal. It is here to be obſerved, that ſeveral ſpecies of lichen yield, in ſome ſeaſons, a kind of ſaccharine effloreſcence upon their leaves, &c.

I. Paper itſelf is nothing more than a kind of fecula proceeding from the portion of liber ſtill mucous and ſucculent, with which the cloth had been fabricated, and which, by being torn, macerated, and boiled for a longer or ſhorter ſpace of time in water, at laſt affords a feculent mucilage, that is collected, by cooling, into a thin layer ſufficiently ſolid to oppoſe a certain reſiſtance to its being torn. This is the baſe of the facts upon which the art of paper-making is founded. This matter comports itſelf, in its chemical analyſis, abſolutely like the fecula; it affords pyromucous acid in diſtillation, and oxalic acid by the nitric acid. It is ſoluble in hot water, forms a jelly or paſte in this operation, and not to ſpeak in this place of the glue, frequently of an animal nature, with which it is covered in order to prevent it from imbibing the ink into its pores, and to render it fit for writing upon, it is evident that this ſolution of paper in boiling water might be ufed as food in cafes where preffing neceffity might oblige men to have recourfe to it.

F. *Ufes of the Fecula.*

32. WHAT I have hitherto obferved with refpect to the feat, the extraction, the chemical properties, and the different fpecies of amylaceous fecula, muft have rendered it evident that this product of vegetation, confidered fo improperly as a kind of earth by the ancient chemifts, is a particular oxide, a natural compound of carbon, hidrogen and oxigen, and perhaps even of a little azote, which has efpecially the great advantage of ferving in an eminent degree for the nourifhment of animals. Accordingly, all the parts of plants which contain it are the prey of numerous claffes of thefe animated beings, from man down to the infects, the larvae and the worms which feize upon them, form their abode in them, and deftroy them more or lefs completely with the different inftruments of manducation with which nature has provided them.

33. It is from the fecula that man derives an aliment, the moft abundant, the moft nourifhing, and the moft eafy to be preferved. Whilft immenfe tribes of animals devour this fubftance pure, and fuch as nature prefents it to them, man knows how to give it a thoufand dif-

different forms, from the moft fimple baking or boiling, to that fo highly perfected preparation known amongft the inhabitants of the temperate zones by the name of *bread*; from the caffava of the Americans to thofe confectionaries, fo delicate, fo light, fo fweet and pleafant to the tafte, which are made in fome parts of Europe, efpecially in France, in Italy, and in Germany. This primitive aliment admits of all combinations with the oils, butter, milk, cheefe, eggs, fugar, aromatic fubftances, the juices of fruits, the juices of flefh; its natural mildnefs and infipidity render it the appropriate recipient of a multitude of condiments.

34. Endowed with this knowledge of the eminently nourifhing property of the amylaceous fecula, men at once enlightened and philanthropic, (for thefe two qualities are rarely divided,) may render effential fervices to fociety by greatly multiplying the fources of alimentary matter, and fhowing that a very numerous feries of vegetable fubftances, which are not generally employed for this purpofe, may be very eafily and fuccefsfully appropriated to it. It is efpecially in times of fcarcity, after the unfavourable feafons which too frequently deprive the people of their hopes of obtaining fufficient provifion for their fubfiftence, that all the aid which chemiftry can afford ought to be called in to the relief of nations. A fatisfactory idea of the important fervices which it

it is able to afford may be derived from reading ſeveral modern chemical works, eſpecially thoſe of Citizen Parmentier, who has deſerved ſo well of his country and of humanity in general, by occupying himſelf with a perſeverance which philanthropy alone could inſtigate, in the inveſtigation of all the alimentary reſources which nations may derive from the culture of the potatoe, of Turkey-wheat, or Maize, and of many other vegetable ſubſtances that have been too much neglected, notwithſtanding all the advantages which they promiſe.

35. A multitude of other ſecondary utilities accompany this firſt utility of the feculas, and render them one of the moſt valuable ſubſtances which man can derive from vegetables. Medicine has borrowed from them not only a variety of foods well appropriated to a multitude of particular circumſtances of diſeaſes, but alſo mollifying, incraſſant, agglutinating remedies, preparations adapted for allaying irritation and pain. It is ſufficiently known what advantage the art of healing derives from different farina, from the fecula of the potatoe, of ſago, of ſalep, &c. It is true that the moſt of theſe preparations have been too much extolled; and that by endeavouring to attribute to them almoſt ſupernatural and miraculous virtues, a part of the confidence which they merit has been deſtroyed. But enlightened phyſicians, equally remote from ridiculous enthuſiaſm and dange-

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rous indifference, employ them with the greateſt advantage.

36. Finally, the arts perpetually employ the amylaceous fecula for a multitude of uſes or render them of important ſervice. By ebullition in water, they are made into glues, or paſtes, which ſerve to keep together a number of ſurfaces of light bodies applied the one over the other, and to effect between them an approximation and coheſion neceſſary in a multitude of circumſtances. They are alſo employed as drying ſubſtances, eſpecially for the hair: for this purpoſe what is called *hair-powder* is prepared from them; a kind of cuſtom, perhaps very ridiculous, of ſeveral modern nations, in which they imitate, without being aware of it, the nations whom they term barbarous, and by which, a circumſtance of great importance, they entirely laviſh away a very conſiderable portion of the ſubſiſtence of a great number of families: it is proper, therefore, to employ for this purpoſe ſuch feculas as are not uſed as food.

ARTICLE IX.

Of the ſixth of the immediate Materials of Vegetables; of the Gluten.

A. *Situation.*

1. THOUGH it is eſpecially in the farina of wheat that we find the glutinous ſubſtance, or the matter diſcovered by Beccari and Keſſelmeyer, and named by them *glutinous vegeto-animal* matter; though it can only be extracted from the farina of this plant, it is allowed by all chemiſts that the cereal grains contain a certain quantity of it, and that it cannot be ſeparated from them, becauſe it either exiſts in them in too little abundance, or too much diſſeminated in the amilaceous fecula or ſtarch.

2. Rouelle the younger, who had eſpecially examined and compared it with animal matters, affirms that he had found it in the coloured fecula, and eſpecially in that which was termed *the green fecula of plants*. But the expreſſion of fecula, applied indiſcriminately to the juices of the plants and to the ſtarch, having led chemiſts to conſider the latter as a part of the remains of ſolid vegetable ſubſtances, there is reaſon to believe that it was merely from analogy, and alſo from ſome equivocal properties that Rouelle imagined that the green matter contained the glutinous ſubſtance. At leaſt the experiments that have been made ſince his time, ſuch as I have ſeveral times repeated upon

these coloured feculas, have not afforded me the confirmation of this assertion, and no fact has really proved the glutinous matter to be one of the principles of this latter fecula.

3. There is a more exact and more positive observation relative to the presence of this glutinous matter in the vegetable texture which forms linen and paper. Citizen Desmarets has observed in the paper manufactories, after the heating or rotting of the rags, and when this substance is melted and softened in water, that thick, solid, insoluble flakes of real gluten are separated. An analogous phenomenon is observed in the work of laundresses. The alkaline leys and the water charged with soap which they employ for washing linen, especially finer linen, take from it a principle which separates, in sufficient abundance, in the drains into which they throw these liquids to choke them up, to stop up the grates which intercept their continuity, and to prevent these liquids from running. There are also found upon these grates, flakes, or masses almost solid, rather soft and ductile, manifestly precipitated from the leys, and separated from the texture of the linen itself. By this means also this texture is gradually worn, rendered thinner and made to lose its weight and form.

4. Lastly, Citizen Deyeux has thought he has discovered the existence of the glutinous substance, in the saps of the yoke-elm and the birch; he has even thought that this sub-

ſubſtance is diſſolved in them by the medidiation of the acetous acid, and that it was obtained precipitated from theſe liquors in inſoluble and ſolid flakes, only by the evaporation or the diſſipation of this acid. I muſt, however, obſerve, that Citizen Vauquelin, who has examined the ſame liquids, did not find them to contain the glutinous principle, but only extract. It is true that this may depend upon the difference of the ſaps which thoſe two chemiſts have examined, and that of the trees which afforded them.

5. It muſt be concluded, from what I have juſt ſet forth reſpecting the almoſt excluſive ſeat of the glutinous principle in the farina of wheat, that this ſubſtance is, perhaps, of all the immediate materials of vegetables, that which is the moſt rarely found in plants, or at leaſt that which is extracted with the moſt difficulty, which is either leſs abundant than many others, or more intimately mixed or combined with other materials, ſo that it cannot be ſeparated without the greateſt difficulty.

B. *Extraction.*

6. The glutinous principle is extracted by proceſſes ſimilar to thoſe that have already been deſcribed in ſeveral of the preceding articles, and which, being dependant upon mechanical operations, cannot change its nature or alter its compoſition. The manner in which this principle is extracted

extracted from the farina of wheat, is one of the moft fimple and ingenious, and at the fame time the moft exact. It is by feparating the ftarch from this farina that we feparate the glutinous principle.

7. Scarcely has a little water been thrown upon the farina, which, as I have already obferved, alone prefents this remarkable character, when its particles approach, adhere, and ftick to each other, forming a mild, gluey, homogeneous pafte, eafy to be kneaded, tenacious, elaftic, which may be elongated, flattened, drawn in every direction, without breaking or cracking. This pafte, wafhed in a fmall ftream of water, and gently kneaded or worked, immediately by the hand of the operator, or well preffed in a bag of linen, equally expofed to a ftream of water, fuffers this liquid to carry away the amylaceous fecula in the form of a white powder, which renders it milky. In proportion as the water carries away this ftarch, the pafte affumes a more grey colour, lefs brilliant as it were, femi-tranfparent, and alfo of a fofter confiftence, but at the fame time more tenacious, more vifcid, more gluey, and more elaftic. In this manner we continue to knead the pafte of the wheat, till the water paffes off clear, and without any feculent powder. Thus the farina is feparated in three fubftances, the ftarch, which is precipitated in a white powder at the bottom of the water, another which remains diffolved in the liquid, and the third which remains foft, cohefive, and elaftic.

8. It

8. It is evident that this glutinous matter, which was in the ftate of powder in the farina, affumes at the very inftant in which the pafte is formed by the addition of water, the gluey and elaftic ftate which it did not before poffefs; that the ftarch which then adheres to it but feebly, and which feems to have covered only the exterior fibrous fafciæ, is detached from it by mere contact of the water, and that the water contributes to its pafty and ductile ftate. It is no lefs certain, that it is to this property of the pulverulent particles of the gluten to become elaftic by the addition of water, that the farina of wheat owes that of forming of a pafte, and that it is in proportion to its quantity, that the panification, more or lefs fenfible in this farina, varies according to the ftate of maturity, the nature of the corn, and that of the foil, the feafon, and all the circumftances relative to the vegetation of this important plant.

9. It is very remarkable, that the gluten feems to difappear, or at leaft can no more be feparated or extracted from the farina of wheat; if inftead of adding at firft little water, and forming a thick, ductile dough, which is afterwards wafhed with a fmall ftream of water, we fuddenly fteep it in a large quantity of this liquid, and reduce it to pafte; we then, indeed, give this liquid, by means of heat, the property of forming a vifcid, thick, very gluey, and opaque mafs, as is done in the preparation of pafte; but we deprive it of that of feparating and infulating the glutinous matter from the ftarch.

ſtarch. It ſeems that by this dilution with a large quantity of water, we entirely inſulate the particles of this body, diſperſe them among that of the fecula, and prevent them from approaching and adhering together, as they do in the ſimple ſtate of dough. Hence it happens, that in theſe paſtes of the flour of wheat, with which wafers, vermicelli, lozenges, &c. are prepared, we can no longer, according to the experiments of Macquer and Pelletier, find again the gluten, and obtain it in the ſame manner as in the thick ductile paſtes, waſhed by means of a ſmall ſtream of water: thus the quantity of this liquid and the manner in which it is employed, has a ſingular influence upon the extraction of the gluten.

10. When the ſolid and ductile dough of the flour of wheat is left to itſelf, at a temperature of at leaſt fifteen degrees, inſtead of being waſhed with a ſmall quantity of water, in order immediately to extract the gluten from it, it quickly undergoes an inteſtine motion, which is not remarked in ſtarch equally impregnated with water; it becomes inflated and filled with cavities, produced by the diſengagement of an elaſtic fluid, and proceeds quickly towards aceſcency. This motion is accelerated by adding to the paſte a portion of a ferment taken from dough that has already riſen, or from the yeaſt of beer, as is practiſed in the fabrication of bread. If the dough be baked before it has undergone this motion, we obtain no real light bread, filled with cavities, and eaſy,

eafy of digeftion; but a kind of thick, heavy cake, much more difficult to be digefted. As ftarch alone does not prefent this phenomenon, it has been thought that the prefence of the glutinous matter was the caufe of it. Accordingly, by adding glutinous matter artificially to a pure amylaceous fecula, which contains none of it, whether it proceed from the farina of wheat, or have been extracted from any other vegetable matter, we form a dough which rifes and affords real bread by baking. It is fo true, that the gluten contributes to this panary fermentation, and is the real fource of it, that well made dough fcarcely furnifhes any more of it after having fermented, and affords none at all after the baking of the bread, though this gives out, in its analyfis by fire, a proportion of ammonia fufficiently confiderable to diftinguifh its products very well from thofe of pure fecula.

11. It is to the fame abfence, or at leaft to the fmall quantity of the glutinous matter contained in the farina of rye, of barley, of oats, and efpecially of maize, of rice, of millet, and of all the other cereal grains, that we muft attribute the impoffibility of making good bread, well rifen, light and porous, with thefe farinas. Still lefs can we prepare any other than crude, heavy, infipid cakes, with the farina, from powders of leguminous feeds, of the feculent roots, and of all the amylaceous vegetable powders deprived of the glutinous principle. It would be very in-

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tereſting to know, whether this principle of the gluten exiſts in the farina of the lichens, with which pretty good bread is made. The only fact well aſcertained reſpecting theſe different farinas, ſo different from that of wheat, is, that none of them forms like the latter a real dough, coheſive and ductile, nor affords a ſimilar quantity of glutinous matter, when waſhed with water, added by degrees. We hardly find any traces of it in the farinas of rye and of barley, which, however, approach the neareſt to that of wheat in their property of forming dough, by the tenacity and coheſion which they acquire by kneading. We find no veſtige of it in the farina of rice, of maize, of millet, &c. We eaſily judge of the ſmall proportion of the gluten contained in theſe different ſpecies of farina, by the nature of the dough, which is obtained by kneading them. The leſs they contain of it, the more the dough which they yield is dry, brittle, not ductile, difficult to be kneaded, the more it cracks, dries, and becomes covered at its ſurface with a brittle cruſt; the leſs they alſo riſe when kept at a temperature of fifteen degrees.

12. The property of forming a good dough is ſo cloſely connected with the preſence of the gluten in the farina of wheat, that this farina itſelf preſents variations in this property relative to the quantity of this matter which it contains. In fact we may judge of the goodneſs of this farina, of the maturity and of the

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good qualities of the corn which furnifhes it, either by the manner in which it comports itfelf in kneading, or which is a much more certain method than the firft, by the proportion of glutinous matter that is extracted from it by the procefs which I have defcribed. Chemifts have already found remarkable differences between the various kinds of farina of wheat, according to their qualities, the nature of the corn, that of the foil in which it has been reared, that of the year, and the feafons in which it has vegetated; and it were much to be wifhed that their refearches relative to this fubject might be further profecuted, as they may afford a fure means of diftinguifhing the qualities of the farina, and determining their nutritive properties. Beccari has already obferved, that the proportion of the gluten varies in the farina of wheat from a fifth to a third. In proportion as the farina of wheat is altered and deteriorated, which happens, as it is known, when it is kept too much compreffed, without being ftirred and aired, in hot and moift repofitories; in proportion as it becomes heated, as it affumes odour, in a word as it ferments, its property of affording gluten is at the fame time diminifhed; and when it is very much altered, it affords only fome detached flakes, which can no longer be made to cohere, of which we can no longer form a fingle mafs, a ductile whole. Accordingly this very eafy and fimple operation of extracting the gluten of the farina, becomes

becomes a rigorous and exact test for ascertaining the goodness, the quality, and the good or bad state of this useful matter.

C. *Physical Properties.*

13. The glutinous principle, when properly prepared, resembles no other vegetable matter; it is soft, tenacious, adhesive to the touch when the fingers are dry, elastic, susceptible of elongation when it is drawn, and returning to its former state when left at liberty; of a greyish colour, of a faint taste, and of a smell nearly resembling that of the human sperm, or that of scraped bones when violently rubbed.

14. The elastic property of the gluten is that which characterizes this substance in the most singular manner. When lengthened with the hand, it becomes flat and thin as it is stretched; it assumes the appearance of a white, brilliant and silky membrane, like the aponeuroses, or the membranes of animal bodies. It then exhibits a fibrous texture, the filaments of which seem to be interwoven with and crossing each other.

15. Its gluey property and the strong adhesion which it contracts with many bodies, is also one of its most marked characters. When we attempt to detach it from any substance upon which it is deposited, it is extended into filaments detached from each other, and resembling the texture of felt: its mere aspect is sufficient to show its resemblance with the animal substances

ftances, with which it is found to have a ftriking analogy. It becomes brittle by deficcation, and then it refembles glue.

16. The glutinous matter affumes a yellow and brown colour, and feems to become covered with a layer of oil, by expofure to the light. When it is expofed to a gentle fire, it rifes, fwells, feparates and becomes filled with cavities or bubbles; at laft it dries, without affuming much colour, and preferving the grey caft which diftinguifhes it: it becomes brittle and unalterable by the air, like glue, and all its ductility and elafticity difappear. When placed upon a burning coal, this dry gluten becomes agitated like an animal fibre, fufes, kindles, and burns, fwelling at the fame time with a fetid odour. If it be diftilled dry in a retort, it furnifhes little ammoniacal water, a large quantity of brown, fetid, and thick oil, much folid and cryftallized carbonate of ammonia, a little pruffic acid, likewife in the ammoniacal ftate, with oily carbonated hidrogen gas; and there is left a coal difficult to be incinerated, and in pretty confiderable quantity, fince it amounts to nearly one fifth of the weight of the glutinous matter. Thefe products have all the difagreeable fmell of animal fubftances fubmitted to diftillation; fo that they might be confounded together, and it is very apparent why the firft authors termed this fubftance the *vegeto-animal matter*.

17. Expofed to the air, the gluten dries when the weather is very dry and the fub-

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ſtance in ſmall layers: when the air is moiſt, and the gluten in a maſs, it changes, and putrefies, ſwelling at the ſame time like animal matter. When it is not intirely deprived of ſtarch, when it retains any between its particles, the latter paſſing into the acid fermentation, and retarding the putrefaction of the glutinous matter, reduces it to a ſtate very near reſembling that of cheeſe. Roulle the younger, in his courſe of lectures, exhibited glutinous matter thus prepared, and preſerved by means of ſalt, in a kind of cheeſe ſimilar to that of Gruyere, or of Holland, in its texture, its ſmell, and its taſte.

18. Water does not diſſolve gluten, but even prevents its adheſion to the bodies with which it has the greateſt diſpoſition to cohere. The glutinous matter is preſerved for ſome time under water, in order to prevent the drying of its ſurface, and its alteration by the air. When we boil water upon this ſubſtance, it contracts, and becomes more ſolid than it was before: ſo far from being divided and diſſolved, it ſoon loſes its viſcidity and extenſibility. When we compare this action of the water with that which it exerts upon the molecules of the pulverulent gluten of the farina, which it reduces in ſome meaſure to a ductile ſtate, we ſee that this matter, in the latter ſtate, is ſaturated with water, and cannot imbibe any more.

19. All the acids much diluted with water, even thoſe that are the moſt feeble in their

nature, ſuch as the acetous acid, ſoften the glutinous matter, diſſolve it, and ſuffer it afterwards to be precipitated by the alkalis, but in the form of a matter that has loſt its ductility, and which Macquer imagined to approach to the nature of the mucilages. When the acids are concentrated they act in a very different manner upon this body. The ſulphuric acid gives it a violet colour, blackens it, carbonates it, diſ-hidrogenates it, ſo far as to diſengage from it a very inflammable gas, and to convert it partly into acetous acid, and partly into ammonia. The nitric acid diſengages from it in the cold, azotic gas, as from animal ſubſtances, turns it yellow, converts it in part into malic and oxalic acids, and into yellowiſh, oily, or fatty flakes: this preſents another analogy with the animal ſubſtances. The muriatic acid acts upon it as ſlowly as the ſulphuric acid does quickly, and after remaining long in contact with it, the fluid contains muriate of ammonia.

20. The alkalis when pure, and a little concentrated, diſſolve the gluten with the aid of heat; we may precipitate it from them by the acids, but altered, and no longer elaſtic. When highly concentrated, they convert it into a kind of ſoap, giving it the oily character, and diſengaging from it ammonia, of which they occaſion the inſtantaneous formation, when they are triturated with the gluten. The ſalts, if we except the ſuper-oxigenated muriate of pot-aſh,

which, by mere preſſure, burns and inflames it with detonation, have no other action upon it than to preſerve and to defend it againſt its ſeptic alteration. The metallic oxides, which it reduces more or leſs, decompoſe it by burning, as do alſo the metallic ſolutions.

21. All theſe properties ſhow that the gluten is a ſubſtance very different from the other immediate materials of vegetables, that it approaches very much to the nature of the animal ſubſtances, that it comports itſelf as they do with fire, air, the acids, and the alkalis, eſpecially that it yields ammonia and oil, no leſs abundantly than ſeveral of thoſe ſubſtances; and that beſides the hidrogen, the carbon, and the oxigen which it contains, like all the other vegetable matters, it contains amongſt its elements azote, which ſingularly changes its properties, and gives it all thoſe by which it approaches to the animal compounds.

E. *Species.*

22. Notwithstanding all that chemiſts have advanced for forty years paſt concerning the glutinous matter, which was diſcovered nearly at that period, and concerning its exiſtence in different vegetables, and in different parts of plants, it is very certain that it is only from the farina of wheat that it has been extracted in the ductile, elaſtic, extenſible, and ſoft form which characterizes it. It ſeems even

in this refpect that this plant, the general aliment of fo great a part of mankind, differs remarkably from all other known vegetables, as it is the only one that affords this fingular product.

23. In order, however, to follow what the moft able chemifts have announced or fufpected concerning the prefence of the glutinous matter in feveral other vegetables, I fhall enumerate as fpecies,

A. The elaftic gluten of the farina of wheat.

B. The filamentous or flakey gluten of other cereal farinas, efpecially that of which fome traces are found in barley, in rye, and in oats.

C. The glutinous matter of the green fecula of plants, announced by Rouelle the younger, but not exactly proved; that of linen.

D. That which Citizen Joffe afferts he has extracted from opium, by treating it with water in the fame manner as the dough of flour.

E. The portion of gluten indicated in the fweet or acid faps by Citizen Deyeux.

F. Bird-lime, prepared, as is well known with the fruits of the miffletoe, with the tender bark of the elm and of feveral other trees macerated in water. Though this fubftance has not yet been examined with fufficient attention, it prefents many properties analogous to thofe of the glutinous fubftance.

24. I fhall

24. I ſhall add to this enumeration, that there is prepared in pharmacy, under the very improper and erroneous name of paſte of mallows, a ſort of tenacious, ductile, elaſtic, and as it were glutinous matter, with a ſolution of gum thickened with ſugar, and mixed with white of egg well beaten up; in fact, this mixture is ſoluble in water, though with difficulty. Finally, I ſhall obſerve, that the particular ſpecies of vegetable matter known by the name of caoutchouc, or elaſtic gum, has many of the characters of the glutinous matter, as I ſhall ſhow hereafter.

F. *Uſes.*

25. It has been thought, from the compariſon of the gluten with the animal matters, that this ſubſtance had more eſpecially the nutritive and reſtorative property, that it formed the baſe of the nouriſhment of men who live particularly upon bread, and that in this conſiſted the advantage of wheat over the other alimentary plants. However, the gluten alone, when preſented to animals, is either rejected by them, or it very ſoon diſguſts them; and it appears to be neceſſary that it ſhould be attenuated by fermentation and combined with the amylaceous matter, in order properly to anſwer this important purpoſe.

26. The glutinous matter is ſometimes uſed for glueing together fragments of porcelain, glaſs,

glaſs, and pottery: it was employed for this purpoſe in France long before it had been extracted and examined chemically. It is ſeparated in the laboratories of chemiſtry for the purpoſe of examining its properties and characters. It is not yet known either to what part of the ſeed it belongs in wheat, or what functions it performs in germination, fructification, or vegetation.

ARTICLE X.

Of the Seventh of the immediate Materials of Vegetables; of the Extract or Extractive Matter.

A. *Situation.*

1. THOUGH the name of extract was at firſt applied in pharmacy to all the ſubſtances that were ſeparated or extracted from vegetables; though this expreſſion, which is purely pharmacological, has been particularly appropriated to deſignate medicinal products, as the vegetable analyſis has long been excluſively applied to the preparation of medicines, yet the firſt pharmaceutical chemiſts of more or leſs note, who have occupied themſelves with deducing chemical reſults from pharmaceutical operations, have diſtinguiſhed ſome principal kinds of extract

extracts amongst those which they prepared for medicinal uses.

2. Thus Rouelle has distinguished three principal kinds of extracts, the mucous, the saponaceous, and the resinous extracts. But it is evident from the exposition of the characteristic properties which he attributed to each of these extracts, that they are real mixtures of several of the materials of vegetables which are the causes of these differences, and that though this distinction was of utility for discriminating and separating the extracts pharmaceutically prepared, it was, nevertheless, adapted only to produce a real confusion of ideas under the chemical point of view.

3. Independent of this distinction, which is more luminous for pharmacy than for chemistry, we ought to conceive that the extractive is a particular matter, neither mucous, nor saponaceous, nor resinous, but merely mixed with one or other of these substances, either by the work of Nature herself, or by the processes which are employed for obtaining it; that it may be separated from these bodies with more or less difficulty by chemical means; and that when thus purified, it possesses properties very characteristic, and very different from all the other immediate materials of plants. One of its most marked characters is, that it is found united or mixed with several different substances, and never exists pure in vegetables.

4. The

4. The extract, confidered under this point of view, exifts in many parts of plants, and its feat feems to be every where or in fome refpect indifferent: however, it is particularly found in the green or brown coloured folid parts. Thus the fibrous roots, the trunks and the ftalks, the barks, the leaves, the fruits afford it in greater or lefs abundance: and on this account it has been propofed to make extracts from all plants, and from all their parts, efpecially in a medicinal point of view; and in fact, with the intention of caufing the virtues o the vegetables to pafs into, to be preferved and even concentrated in this preparation, which was termed extract, only becaufe it was confidered as a kind of epitome of the plants themfelves.

B. *Extraction.*

5. As the extract is a matter foluble in water when it is pure and without alteration, it exifts naturally diffolved in the juice or the fap of plants, fo that it is fufficient to evaporate thefe liquids with a gentle heat, and till they affume the folid form, in order to reduce them into extracts; in this ftate they are fometimes termed infpiffated juices, fuch as opium, aloes, the juice of acacia, that of the hypocyftis, of floes, the cachou, the extract of borage, and a number of other juices infpiffated by the nature of

of the climate and the ſun, or by the artificial heat of ſtoves, ovens, &c.

6. Frequently the extractive matter, inſpiſſated by the progreſs of vegetation itſelf, is found in plants in a ſolid ſtate. It is more eſpecially in the roots, the wood, the barks, the ligneous and dry leaves, that the extract exiſts in this ſtate. In theſe caſes, chemiſts have applied cold or hot water to theſe vegetable ſubſtances, and continued this application, till the liquid paſſed off without colour or taſte. This water, when once charged with extractive matter, is evaporated by a gentle heat till it leaves a dry matter, which is the extract.

7. The extracts that are prepared in pharmacy receive different modifications from the artiſt, accordingly as the different mixtures which they contain are more or leſs ſuſceptible of being altered, or of remaining without alteration; for theſe preparations, made in order to be preſerved, ought to be put into a condition not to be decompoſed ſpontaneouſly. On this account, thoſe which are mucous or fermentiſcible are more ſtrongly inſpiſſated or evaporated than thoſe that are bitter and more or leſs reſinous. Hence the different forms and conditions which are given to theſe preparations; ſome are ſoft and like honey; others thick, hard, and dry as the cachou, the juice of liquorice; others in thin, dry, and brittle ſcales, as their ſolution has been evaporated upon plates by the heat of a ſtove: hence the expreſſions of *rob*, *ſapa*; *deſrutum*,

defrutum, *effential falts* of Legaraie, which all have only relative, and often erroneous values. It is even ufeful here to remark, that the greater number of the pharmaceutical extracts are more or lefs altered, burned, or reduced to coal, by the kind of evaporation itfelf, violent and long continued, which they are made to undergo; and that thofe which have been evaporated flowly, have experienced from the atmofpherical oxigen, another kind of alteration of which I fhall foon fpeak.

C. *Phyfical Properties.*

8. THE pure extract is a folid, lamellated, and tranfparent body, when its folution has been evaporated in thin layers, or granulated, and in opaque maffes when its folution has been treated in large quantity by ftrong evaporation, of a brown, more or lefs red or deep colour, of a tafte almoft always more or lefs fenfibly bitter, or acrid, or acerb, and always acid.

9. It is fo rare for the extractive matter to be infulated in the common extracts, that the properties which I have juft indicated in it are fufceptible of a multitude of modifications or variations which prevent their characters being defcribed in an unequivocal manner. However, in feeking thofe characters which have appeared to me to belong in a fpecial manner to the extractive matter, I have found that its affuming the brown colour, and its property of abforbing oxigen

gen which renders it infoluble, were thofe which feemed to belong to it exclufively; that afterwards its tafte, its confiftence, its more or lefs confiderable alterability were modified in it in a very various manner, according to the different quantity and nature of the matters that were naturally combined with it.

D. *Chemical Properties.*

10. THE extract is not in the fame predicament with the moft of the other immediate materials of vegetables; but it has fo long been confounded with fome of them; and mixtures, or combinations of feveral of thefe bodies have fo long been taken for it, that its chemical properties have not been eafily determined, and it is impoffible for me to fet them forth in the fame order, or with the fame method as that which I have hitherto followed for the other materials. I have, however, been the firft who have endeavoured to diffufe fome light over this part of the vegetable analyfis, which has hitherto been fo obfcure and fo much neglected, as may be feen in my Examination of the Cinchona of St. Domingo, inferted in the Annals of Chemiftry. Since that time, Citizen Vauquelin has refumed this ufeful inquiry, and carried it much further. In order to afford an idea of the manner in which he has fucceeded in determining the chemical nature of the extract, I fhall here follow him in the feries of obfervations and

and experiments which have guided him in this inquiry, pointing out what relations ſubſiſt between his labours and that which I had deſcribed at firſt in the work already mentioned.

11. It was by examining the ſap of trees that this chemiſt was conducted to the knowledge of the extractive matter. By conſidering this principle diſſolved in the water of vegetation, he remarks that this liquid, which is colourleſs at the moment when it comes from its canals, aſſumes a more or leſs brown caſt by expoſure to the air; that the expreſſed juices of plants alſo become brown or yellow by the contact of the air and the light; that during their evaporation there is formed at their ſurface a brown or reddiſh pellicle which breaks into flakes, that ſimilar brown flakes preſent themſelves in the midſt of theſe liquids, that this phenomenon taking place equally in the preparation of pharmaceutical extracts, the flakes in queſtion are confuſedly mixed in them with the dried extract, and that when we diſſolve this in water there always remains a portion of brown or blackiſh matter which does not diſſolve; that the longer the evaporation is continued, the more points of contact there are between the air and the extractive liquor, and the more inſoluble matter is formed; ſo that by continuing the ſucceſſive ſolutions and evaporations of the extract, it cannot be doubted that we may at laſt render the whole of this body flaky and inſoluble. Theſe firſt facts intirely agree with what I have

have faid concerning the product of the decoctions of Cinchona of St. Domingo, and of the nature of the extract in general, the principal character of which confifts, according to me, in its abforption of oxigen and the infolubility confequent thereupon.

12. The folutions of all the pharmaceutical extracts redden the tincture of turnfole. Every folution of extract prepared by the evaporation of the juice of a plant yields, by fome drops of ammonia, a precipitate of a more or lefs deep brown colour, formed of lime and the extractive part become infoluble. The concentrated fulphuric acid thrown upon an extract, difengages from it a very penetrating acid vapour, and we extract from it weak acetous acid, by diftilling the mixture of one part of extract with half a part of fulphuric acid diluted with four parts of water. Thus the extracts contain free acetous acid, which renders their tafte four, which caufes them to redden turnfole, and combined acetous acid, which the fulphuric acid difengages from them in much greater abundance. When we mix quick-lime in powder with an extract fteeped in a little water, a pungent vapour of ammonia rifes, which may be obtained from it by diftillation. If, after having diftilled an extract with fulphuric acid, in order to feparate the acetous acid from it, we treat the refiduum with alcohol, which diffolves the extract, we find in the refiduum

fulphate

ſulphate of pot-aſh, ſulphate of lime, and ſulphate of ammonia.

13. It is evident, from the facts, that beſides the mucilage, the ſaccharine ſubſtance, the gelatin, the different vegetable acids, the reſin, which are ſo frequently mixed with the extractive matter in the pharmaceutical extracts, they conſtantly contain acetous acid, acetites of pot-aſh, of lime, and of ammonia. It is alſo known that they frequently contain ſulphate of pot-aſh, muriate of pot-aſh, and ſulphate of lime, the exiſtence and proportion of which may be determined by examining them before treating them with the ſulphuric acid, and comparing the proportion of theſe ſaline products with that which they furniſh after the addition of this foreign acid. To theſe muſt alſo be added the nitrate of pot-aſh, which is found ſo abundantly and ſo frequently in the juices of plants and in their extracts. It is true that this appears to proceed from the ſoil itſelf in which they are rooted.

14. Theſe firſt facts ſtill belong only to the matters which pretty conſtantly accompany the extracts, and are not eſpecially characteriſtic of this principle. However, by calling to recollection that thoſe which I have already attributed to it, are its aſſuming a brown colour by the contact of the air, its precipitation and ſeparation from water, in pellicles, or in inſoluble coloured flakes, by the abſorption of oxigen, and the precipitation of the juices which

which hold them in ſolution by the addition of ammonia; it will appear, that the following facts, added to the former by Citizen Vauquelin, may enable us well to diſtinguiſh the extractive, and to determine its particular nature with greater accuracy than has hitherto been done.

15. When we pour into a ſolution of any extract, ſulphate of alumine of which the exceſs of acid has been ſaturated, and boil this mixture for ſome time, there is formed in the liquid a very abundant flaky precipitate, which is compoſed of alumine and of vegetable matter become inſoluble in water; the ſolution of extract has thereby loſt all its colour. Almoſt all the metallic ſalts produce the ſame effect: the ſolution of tin eſpecially forms in that of the extract a very abundant flaky brown precipitate, compoſed of oxide of tin and of extractive matter, become inſoluble. The oxigenated muriatic acid, poured into a ſolution of extract, forms in it immediately a precipitate of a deep yellow colour, and the liquor has afterwards only a light citron colour, retaining ordinary muriatic acid.

16. When we impregnate cotton or thread, with a ſolution of alum, and afterwards ſteep them in a ſolution of extract, which is then boiled for ſome time, theſe white bodies become ſtrongly tinged with a yellowiſh-brown colour, and are charged with the greater part of the extract, which depoſits itſelf upon their ſurface, and more or leſs completely deſtroy the colour of the

the ſolution, which we may intirely exhauſt of extract by repeating or urging this proceſs. We may ſucceed ſtill better in totally ſeparating the water and precipitating the colouring matter of the extract in a ſolid form upon the cloths, by ſoaking wool, cotton, or thread, for ſome time in oxigenated muriatic acid, and afterwards immerſing them in a ſolution of extract: the oxigen abandons the acid, ſeizes the extract, takes it away from the water, and precipitates it upon the cloth, which alſo exerts a particular attraction upon it.

17. All the extracts, whatever they may be, when ſubjected to diſtillation, yield an acid product, in part ſaturated with ammonia, which contains much more of the latter body than is ſeparated by means of lime or the alkalis. Thus the extract, beſides the portion of ammonia that exiſts ready formed in it, contains alſo the materials of this alkali, which unite by the action of the fire. When ſolutions of extracts in water are left alone, the extractive is ſpontaneouſly decompoſed in them in the courſe of time; the liquors become turbid, depoſit abundant mucous flakes, become covered with different kinds of moulds, diffuſe various odours, yield ammonia, and leave at laſt for fixed products of this putrefaction, carbonates of pot-aſh and of lime.

18. From a compariſon of all theſe facts we may deduce the following reſults:

a. The

a. The pharmaceutical extracts are complex ſubſtances, compoſed of very heterogeneous matters, ſome of which are pretty conſtant, and the others accidental, dependent frequently upon the nature of the ſoil in which the vegetables have been reared.

b. The ſubſtances which conſtantly accompany the extractive matter in the pharmaceutical extracts are free acetous acid, the acetites of potaſh, of lime, and of ammonia. Thoſe which are accidental in them vary in ſuch a manner according to a multitude of different circumſtances, that it is impoſſible to give a ſtatement of them; all the immediate materials of plants that are ſoluble in water belong to this order of accidental bodies in the extracts, and may be found in them one or more at a time: it was according to theſe that Rouelle had made his three claſſes of extracts, but they are very incomplete, inſufficient, and inaccurate.

c. The extract, conſidered ſeparately from all the ſubſtances foreign to its nature, whether conſtant or accidental, is a ſubſtance very different from all the other immediate materials of vegetables; it is characterized by its attraction for oxigen, the manner in which it abſorbs it from the air, from the oxigenated muriatic acid, from the metallic oxides, by the inſolubility which it acquires by combining with it, by the brown colour which it aſſumes in proportion as it unites with it, by its union with alumine, with the metallic oxides,

 and

and by its adhefion to cloths by the aid of thefe mordants, by the feparation of the water, effected by the acetite of lime, which is conftantly mixed with it, and of the ammonia which is added to it; a feparation, which is owing to the double elective attraction of the lime for the extractive matter, with which it is precipitated in an infoluble ftate, and of the ammonia with the acetous acid.

d. The extractive matter is a kind of oxide with a triple radical, or a compound of carbon, of hidrogen, of azote, and of oxigen, which is not faturated with the laft of thofe principles, but can abforb much more than it contains. It approaches very nearly in its properties to the matter which dyers term *colour*, or *colouring matter*, from which it differs only in the proportion of its primitive principles.

e. The property which the pureft extracts poffefs of attracting the humidity of the atmofphere, and of becoming foft when expofed to it, does not belong to the extracts, but only to the acetite of pot-afh which they contain, and we might even determine by their deliquefcence the proportion of this falt which is contained in them. There is reafon to believe, that the virtues admitted by phyficians in the extracts, are owing only to the acetites which are conftantly combined with them, and depend very little upon the extractive matter, properly fo called.

19. It

19. It is not, however, to be inferred from all these facts, that the nature of the extract, supposing it deprived of all the different matters which it contains, is perfectly identical in all vegetables. On the contrary, it is probable that the proportions of these primitive principles vary a little; but that it is not to this primitive variation of principle that we are to ascribe the very striking difference of the virtues which physicians have observed in opium, the extract of cinchona, that of the wild cucumber, of belladonna, of hemlock, of stramonium, substances so different from one another, but that it is rather to some particular matters added, in each of these bodies, to the extractive, properly so called, that their different modes of acting ought to be attributed.

E. *Species.*

20. It must appear, from what has been observed in the preceding numbers (8 to 19,) that the number of the species of extracts may be very considerable, if we should wish to establish between them distinctions founded upon their individual properties. It would then be necessary to admit as many of them as there are different plants capable of furnishing them. According to each particular matter added to the extractive, it would then be necessary singularly to multiply this classification of the

 extracts;

extracts; on the other hand, if we were to consider the extractive matter, properly so called, abstractedly from all the substances that may be added to it, we should then not be in possession of a sufficient stock of knowledge to distinguish with precision the real difference which separates them the one from the other.

21. By holding a sort of middle course between the two limits which the science cannot yet attain, we may continue to employ, but only for pharmaceutical uses, the distinction admitted by Rouelle, namely:

A. *Mucous* inspissated juices or extracts, amongst which are to be ranked the rob of currants, the juice of liquorice, the extract of juniper.

B. *Saponaceous* inspissated juices or extracts, to which are to be referred the juice or the extract of borage, the juice of the acacia, that of hypocistis, of sloes, cachou, and the extract of Peruvian bark.

C. *Extracto-resinous* inspissated juices or extracts, which present amongst their most remarkable species, opium, a very complicated juice, containing, with the extractive matter, an oil and a viscid resin, a mucilage, a gluten, and a salt; aloes, improperly ranked amongst the gum resins, the elaterium, or juice of the wild cucumber; and the extract of rhubarb.

22. We are still far too much in want of experiments upon the pharmaceutical extracts to be able to class even conveniently, though still with

with little accuracy, under one or other of theſe three diviſions, the moſt of thoſe that are prepared and employed in medicine; ſuch as the extracts of gentian, of water-trefoil, of elecampane, hemlock, of belladonna, of pulſatilla, of chervil, of fumitory, of patience, of centaury, of ſuccory, of tormentilla, of ſaffron. I have here mentioned only the principal and the moſt commonly employed of theſe preparations, as the diſpenſatories contain a number of others equally unknown with reſpect to their claſſification.

B. *Uſes.*

23. A MUCH greater uſe was formerly made of extracts in medicine: at preſent, twenty ſpecies at moſt are employed in pharmacy, including thoſe which are prepared in the large way in commerce. We have ſeen that for the greater part, excepting thoſe that are acrid, narcotic, poiſonous, or violently aſtringent and febrifuge, their principal virtues, which are aperient, diſſolvent, and purgative, may be attributed to the acetite of pot-aſh which they contain.

24. We may add to this medicinal uſe, regarded hitherto as the only one in all the works on chemiſtry, that there is another which is much more frequent, and much more important for ſociety, namely, that which is made of the extracts in dyeing. All thoſe ſubſtances which dyers call colours of roots, or even of woods, are

are nothing elſe but extracts in ſolution, in which they dip and keep immerſed for a longer or ſhorter ſpace of time during their ebullition, threads and ſtuffs previouſly impregnated with ſolution of alum, or ſome other mordant, in order to precipitate and fix upon them the extractive matter. I ſhall revert to this ſubject in one of the ſubſequent articles.

ARTICLE XI.

Of the Eighth of the immediate Materials of Vegetables; of the Fixed Oils.

A. *Situation.*

1. OIL, or the oily ſubſtance, in general, is one of the immediate materials of vegetables, the leaſt ſoluble in water, and is eminently diſtinguiſhed from all others by its combuſtible property, and by the bright flame which it emits during its combuſtion. It is long ſince it was firſt remarked that the oil formed by vegetables is one of the products of vegetation, that there is no mineral oil, properly ſo called, and that what is ſometimes found amongſt the foſſils originates from plants, and cannot be compoſed in the bowels of the earth.

2. The ſpecial and diſtinctive character of fixed oil is, that it is not raiſed eaſily, and without alteration into vapour by the action of fire; and it is oppoſed by this character to volatile oil.

oil. It was formerly termed fat oil, *oleum unguinofum*, or mild oil, as it enjoys both thefe properties; and expreffed oil, becaufe it is conftantly obtained by expreffion.

3. Amongft the properties by which it is diftinguifhed, I efpecially remark that of being contained only in a fingle part of the vegetables; namely, in their feeds. It would be in vain to look for it in other organs; it is never found either in the roots, the ftalks, the barks, the leaves, or the flowers. Sometimes, though rarely, it is fituated in the parenchyma, or the pulp of certain fruits; moreover, amongft the numerous oleiferous plants of our climates only the olive can be mentioned, as containing it in its foft external fkin, and on the outfide of its kernel. Generally it exifts only in the cotyledons, and it is even found only in thofe that have two cotyledons. I know no example of a monocotyledonal plant with an oily feed.

4. All the dicotyledonal feeds that contain oil, are at the fame time charged with mucilage and fecula, and they have all a character by which they may be diftinguifhed; namely, that of forming with water in which they are triturated, a white liquor which is termed emulfion, milk of almonds; on which account they are termed emulfive feeds. They manifeftly owe this property to the oil which they contain between the particles of their parenchyma. The water, by diffolving the mucilage, and difperfing in fome meafure between its own par-

 ticles,

ticles, thoſe of the ſtarch, retains in ſuſpenſion ſmall drops of oil, which deſtroy its tranſparency, and give it a milky opacity and whiteneſs. Accordingly, when this milk of almonds is kept for a long time in contact with the air, a portion of the oil ſeparates at its ſurface in the form of a greyiſh or ſemi-tranſparent cream; this layer ſeparated at the ſurface, forms, even at the end of ſome days, real oily drops. During this ſeparation a portion of the fecula is depoſited in a white powder, and the liquor becomes clear in proportion as this double ſeparation of the two ſubſtances, that were diſſeminated in it, is effected by repoſe. The acids bring about this kind of decompoſition in a much more ſpeedy and powerful manner.

5. This excluſive preſence of the fixed oil in the interior of the dicotyledonal ſeeds, is a fact that has not yet ſufficiently engaged the attention of chemiſts. It may, however, throw ſome light upon ſeveral parts of vegetable phyſics, as it manifeſtly depends upon the ſtructure, the intimate nature, and the functions of the ſeeds. I ſhall content myſelf with obſerving here, in a general manner, that the fixed oil, which is mild and nutritious, accompanies the embryo in the ſeed like the chick in the egg: that it is ſituated in a particular place in theſe ſeeds, like the oil of the egg in the yolk: that it gives to the maſs of cotyledons the property of forming with water a kind of vegetable milk, like that the egg gives to the yolk, the

the property of forming with water what is termed pretty accurately *lait de poule*; finally, that it contributes, in the period of germination, to the firſt nouriſhment of the plant, as the yolk ſerves for the nutrition of the chick during incubation, and previous to its leaving the egg, and that it ſeems to characterize the dicotyledonal plants in oppoſition to the monocolytedonal, in the ſame manner as the oviparous animals, whoſe young enjoy only this kind of lactation in the egg, are oppoſed to the viviparous, which receive milk from the mother after they have left the uterus.

B. Extraction.

6. FIXED oil being contained ready formed in the parenchyma of the ſeeds, or of ſome fruits, nothing more is required than to preſs this parenchyma more or leſs forcibly, in order to make it run out, and to obtain it ſeparate. But the manner itſelf in which it is contained or incloſed in the parenchyma, its abundance compared with that of the other ſubſtances that are mixed with it, or with which its particles are ſurrounded, its more or leſs liquid ſtate, and its greater or leſs diſpoſition to run, are many circumſtances that muſt influence the art of extracting it, and determine modifications in the practice of this art.

7. Frequently nothing more is neceſſary than to bruiſe the ſeeds, reduce them to a kind of pulp or cake, afterwards to ſubject this paſte,

incloſed

inclosed in sacks of hair, or cloth, to the action of the press, in order to cause the oil to run out in such a manner that it can easily be collected. This is the operation practised in the pharmaceutical laboratories, in order to obtain the oil of almonds, and the oil of linseed; they are then termed cold-drawn oils, and a similar or equally simple process is followed for extracting the oil of hazelnuts, of walnuts, of hemp-seed, of colza, of rape seed, even the oil of olive, the oil of beech-mast, the oil of poppy seed, and a great number of others analogous to these in their nature and their uses.

8. But it is observed that most of the seeds yeild by this process only a small quantity of oil, and that though it is very pure, and very mild, such as is requisite for medicinal uses, it is too dear on account of its scarcity for most of the purposes of life, or the arts for which it is destined. We even meet with some seeds, which, containing together with the oil, a more or less considerable quantity of gummy mucilage, or of light and highly divided fecula, yield hardly any oil by the mere pressure of their paste in the cold, or else yield it only with extreme difficulty. Those even from which all the mild and fixed oil which they are capable of affording, has been extracted by the first process, still retain a portion in sufficient quantity for it to be possible to obtain much from them by a second manipulation.

9. In the cafe which I have juft indicated, a more or lefs violent heat is employed, according to the fubftances which we have to treat, according to the more or lefs condenfed nature of the oil which they contain, of the fecula, or of the mucilage, of the receptacle, from which they muft be extracted, according to the more or lefs important ufes to which they are deftined. Sometimes we content ourfelves with heating plates of block tin, which are applied immediately to the pafte of the feeds, and which comprefs them by the approximation of the peices of the prefs, in order to give more fluidity to the oil, as is done with the fweet almonds; at other times the pafte itfelf is expofed to the vapour of boiling water, in order to penetrate it with a gentle heat, which favours the feparation and the efcape of the oily juice. For the lefs important oils, the feeds are more or lefs ftrongly roafted, in order to thicken or dry their mucilage and fecula, to bring the oily molecules to their furface, and to begin to caufe the drops to exfude outwards. This laft procefs is particularly employed for the very mucous and very vifcid feeds, which at the fame time contain a large quantity of water. The oils that are extracted by this manipulation, which is employed for linfeed, and hemp-feed, are lefs pure, lefs mild, and lefs fine than the firft; they are alfo more coloured; but they are at the fame time more abundant and more eafily preferved. When the

the feeds have been too much roafted, the oil is reddifh and has a more or lefs ftrong empyreumatic tafte.

10. The fixed oil that is obtained by the proceffes that have been indicated, is always mixed, and even combined with fome foreign fubftances, and efpecially with mucilage, amylaceous fecula, and colouring matter. Frequently thefe three bodies, and efpecially the two latter are fpontaneoufly depofited from the oily liquid, when it is kept at reft for fome time; we fee mucous flakes, coloured fibrils, or flight feculent powders gradually precipitated to the bottom of thefe oils; thefe, which at firft were opaque or turbid, at the moment when the action of the prefs expelled them from the pafte of the feeds, become clear, and more or lefs tranfparent and pure when left to themfelves. The grofs portion of the parenchyma, which has been carried along with the firft portions of expreffed oil, is feparated and precipitated firft, afterwards the green and coloured fecula, then the amylaceous fecula; and the gummy mucilage is depofited the laft, but frequently there even remains a portion in real folution or combination with the oily juice: it is this portion which forms what Scheele has termed the fweet principle of the oils, of which I fhall fpeak hereafter. It is this that gives to the oil, when burned, the thick flakes which render it turbid, and more or lefs diminifh its combuftibility. Sometimes a por-

a portion of the green fecula, as we fee in the oil of olives, remains in folution in this body, and communicates to it the colour and the tafte of the fruit.

11. We fee from what has been faid that mere repofe is not always fufficient for purifying the oils; filtration through fieves or linen, with more or lefs wide interftices for feparating the groffer part, is likewife only a mechanical means, which takes away merely the foreign matters which are interpofed: the effect of time feparates indeed, efpecially with certain oils, a portion of the mucilage or of the light fecula which are diffolved in them; but there is another part, and fome oils contain a large quantity of it, which remains really diffolved in them, and is never feparated from them by reft, at leaft unlefs the oil itfelf undergoes an alteration, and communicates to thefe bodies properties which oppofe the combination of advantages which we expect from them. It is efpecially in order to render them more pure and more eafily as well as more completely combuftible that we endeavour, by different proceffes, to free them from the foreign fubftances that are combined with them. Chemiftry has not yet exactly determined the different ftates of lamp-oils, and the real caufes of their bad qualities. The proceffes alfo that are employed in fome manufactories or work-fhops for purifying thefe oils are a kind of empirical practices, or methods which Science has not yet examined.

 12. Thefe

12. Thefe proceffes of the arts or of the work-fhops in which oil is employed are very much diverfified, and frequently conftitute a kind of fecret. It appears that in fome, after having fuffered the oils to reft, and filtrated them, they beat them up with water; in others they heat them gently for a longer or fhorter fpace of time. There are fome in which the oils are treated by acids diluted with water; and this procefs muft in fact feparate the mucilage from them. There are others in which they are treated by lime or the alkalis, which appear to abforb an acid holding mucilage in folution, and to favour the precipitation of this mucilage. It is alfo afferted that in fome work-fhops they ufe alum, whilft in others they employ chalk, gypfum, argil, or afhes for effecting the purification of the oils. It is evident that if each of thefe means fucceeds, it is to be concluded, that the matters which render the oils impure muft vary according to the fpecies; but it is of much greater importance to be obferved that an accurate chemical examination of thefe liquids will alone enable us to throw upon this fubject the light which the fcience is capable of diffufing over it, and that after fuch an examination this art fo ufeful to fociety will no longer be involved in obfcurity.

C. *Phyſical Properties.*

13. Fixed oil is generally a liquid rather thick or viſcid, forming ſtreaks that adhere to glaſs, of a mild or inſipid taſte, ſometimes a little acerb, or analogous to that of the plant from which it proceeds; without any peculiar ſmell, but frequently alſo impregnated with that of the ſeed from which it has been extracted.

14. Fixed oil is never entirely void of colour; frequently it has a greeniſh or yellowiſh hue: that which is green when recent, loſes this caſt in the courſe of time, and aſſumes a yellow ſhade, which at length becomes deeper and inclines towards the orange or the red. In general it is lighter than water, ſwims upon its ſurface; and its ſpecific gravity, taking that of water at 10000, varies between 9403 for linſeed oil, and 9153 for olive oil.

15. This body, when expoſed to the cold, congeals and even cryſtallizes, or aſſumes a ſolid and granulated form by cooling; but this property varies in it in a ſingular manner according to the ſpecies: there are ſome that become fixed at five or ſix degrees above 0, and others, on the contrary, are not congealed, unleſs at 10 or 12 degrees below 0; there are even ſome that never become ſolid by the effect of cold. It is generally obſerved that thoſe which become fixed the moſt ſpeedily, like the oil of olives, are the leaſt alterable, the leaſt

leaſt ſubject to change, and that, on the contrary, thoſe which are very difficult to be congealed, are the moſt ſubject to ſpoil, to become rancid, &c.

D. *Chemical Properties.*

16. Fixed oil, expoſed to the fire, is not volatilized unleſs when it is boiling, and hence it derives its name; but in this volatilization it is altered, loſes ſome of its principles, tends to be decompoſed; the carbon is partly inſulated in proportion as the oil is heated; the volatilized portion is more hidrogenated and lighter; water is formed, and an acid analogous to that of the fats, which is termed *ſebacic.* There remains in the retort black and coaly traces; and carbonated hidrogen gas is diſengaged. Such is the collection of the phenomena which take place in the diſtillation of the oils, which the ancient chemiſts performed in order to obtain what they termed the oil of Philoſophers. The volume of the air contained in the apparatuſes contributed alſo to its production in a more or leſs efficacious manner, becauſe there is more water formed, and carbon inſulated, as the capacity of the diſtilling veſſels is larger; ſo that by repeating the diſtillation of the ſame oil a great number of times in new apparatuſes, we at laſt conſtantly reduce it almoſt entirely into water, carbonic acid, carbonated hidrogen gas, and coal.

17. The

17. The phenomena of the combuſtion of oils, when heated in contact with the air, are the ſame as the preceding, except that its decompoſition is more rapid and more complete. It is well known that they cannot be burned unleſs when violently heated, that the uſe of the wick employed in lamps is to raiſe the oil in vapour by ſucceſſive portions; that in the ingenious lamp of Argand and Lange, by diſpoſing the wick in a circular form, and ſurrounding it with a double current of air, by increaſing the activity of this by the addition of a tranſparent tube of glaſs round the wick, and eſpecially by giving this tube a contraction at the very place where the extremity of the wick uſually exhales ſmoke, the combuſtion of the oil is rendered much more complete and rapid, the flame more brilliant, the ſmoke and ſmell annihilated, as both are intirely deſtroyed, and that the product of this complete combuſtion is only water and carbonic acid. 100 parts of oil ought to yield 130 parts of water, as they contain, according to Lavoiſier, 21 parts of hidrogen, and 203 of carbonic acid, ſince they contain according to the ſame author 79 parts of carbon; now the ſum of theſe two products being 333, 233 parts of oxigen muſt be added to 100 parts of oil in order to make it burn. This reſult, which certainly is not very accurate, but which approaches to the truth as near as can be, in a firſt experiment, ſuppoſes indeed that there is no oxigen in a fixed oil, that it is com-

compofed only of carbon and hidrogen, and it is probable that it includes fome error in this point of view; but it is certain and well afcertained that oil is reduced only into water and carbonic acid by combuftion, and that it affords more water and likewife more carbonic acid than its own weight.

18. A very different effect takes place with the fixed oil when expofed to the air without heating it, as to inflame it; it gradually thickens, becomes concrete, opake, white, granulated and fimilar to tallow. This change takes place very quickly, and requires only fome days, if we greatly extend the oil upon the furface of water, as Citizen Berthollet has difcovered. This effect is owing to the oxigen which they flowly abforb; they become a kind of wax; they even experience this alteration in the living vegetables, by a difpofition which I fhall defcribe in the next article. Some fixed oils become dry, and thefe are termed drying oils. Some undergo the cerification or febification very quickly; others, on the contrary, very flowly; fome as they thicken affume a febacic character which manifefts itfelf in their tafte and fmell; they are then rancid, redden the blue vegetable colours, and are unfit to be ufed as food or condiment: there is alfo formed at the fame time a fmall quantity of water which appears in fmall drops at the furface, or evaporates into the air. There take place, therefore, in this

flow

ſlow action of the air three very diſtinct effects upon the fixed oils. The firſt is a ſimple abſorption of the atmoſpheric oxigen, which thickens them and tends to convert them into wax; the ſecond is a diſengagement of their hidrogen, which burns at their ſurface, forms water, and dries them themſelves without cerifying them; the third is the production of the ſebacic acid which depends upon a new union, and in a determinate proportion, of hidrogen, of carbon and of oxigen: this conſtitutes rancidity. Every ſpecies of fixed oil experiences in a different manner one or other of theſe effects, ſometimes inſulated, ſometimes combined; ſo that ſome are cerifiable, others drying, and the third rанceſcent. There are ſome that do not undergo any of theſe alterations without much difficulty. Theſe different modifications in the alterability of the oils depend upon their primitive combination, or the proportion of their elementary conſtitution, and it will be eaſy to aſcertain their difference and their cauſe, when an analyſis ſhall have been inſtituted of the principal ſpecies that belong to one or the other of theſe genera; for it ſhall be ſhown hereafter that in order to diſtinguiſh the ſpecies it is neceſſary to divide them according to theſe properties.

19. The ſimple combuſtible bodies unite more or leſs eaſily with fixed oil; hidrogen in the ſtate of gas does not unite with it unleſs with difficulty.

Carbon in the ſtate of coal, through which oil is filtrated, contributes to purify or whiten it, without ſenſibly uniting with it.

Phoſphorus unites with the oils by the aid of heat; it fuſes and diſſolves in them in a ſmall proportion, communicating to them the luminous property when they are rubbed in the air; and it is this ſolution which is employed for rendering any ſurfaces luminous and phoſphoric in the dark. When we diſſolve in heat all the phoſphorus which the oil is capable of diſſolving, by letting it cool, a part of the phoſphorus is depoſited by the refrigeration, and cryſtallizes in tranſparent octahedrons. By diſtilling the phoſphorated oil, we obtain phoſphorated hidrogen gas.

Sulphur combines eaſily with fixed oil by means of heat; whence reſults a reddiſh ſolution which has formerly been termed *Ruby of Sulphur*, on account of its colour. This ſolution depoſits cryſtallized ſulphur by refrigeration; it is even the only proceſs by which Pelletier has obtained the ſulphur cryſtallized in octahedrons. When the refrigeration is too rapid, yellow ſulphur is precipitated in needles. If we diſtil this ſulphurated oil, which has a fetid ſmell, a large quantity of ſulphurated hidrogen gas is obtained, without the ſulphur ſubliming in its concrete and inſulated ſtate.

Some oils exert an action upon the metals that are the moſt eaſily oxidated; they accelerate their oxidation, and favour the abſorption of of the atmofpheric oxigen; but this effect is in general feeble and flow. The metallic oxides have a much more marked action upon the vegetable combuftibles; by the aid of heat, they yield a portion of their oxigen to the oils, which then become thickened, and form in general the fubftances known by the name of *plafters.* In this ftate they form kinds of foaps frequently infoluble, fometimes more or lefs foluble. If we augment this action by that of heat, we intirely decompofe the metallic oxide; it paffes again into the ftate of metal, and the oil is then intirely deftroyed into water, and carbonic acid. It is this which caufes plafters to affume a coppery-red colour, and moft of the ointments, or plafters, that have been too long boiled, acquire a brown or blackifh colour, by the reduction of the oxide of lead.

20. Water has no fenfible action upon the fixed oils; they remain upon the furface of this liquid. When agitated with it, they firft whiten it and interpofe themfelves between its particles; but they feparate again from it by repofe. Water, however, takes from them a certain proportion of mucilage, and favours the feparation of the colouring fecula, which troubles their tranfparency; this is a means ufed in work-fhops for purifying them and rendering them more combuftible.

21. The acids are capable of decompofing the fixed oils, but with particular phenomena, according to the nature and the concentration of

thefe

theſe acids, as well as their quantity and different temperature. In general, the concentrated ſulphuric acid renders theſe oils brown, thick, and reduces them to coal. This action has formerly been compared to the formation of a reſin, or of a bitumen; but it is really neither the one or the other; it is a commencement of decompoſition, in which water is formed; carbon is ſeparated and precipitated, and even an acid is produced. The cold nitric acid thickens and ſlightly oxidates them; if it be mixed with nitrous gas, it acts with much greater activity; it excites a conſiderable ebullition and effervefcence, and a large quantity of nitrous gas is diſengaged. When we throw upon oils a mixture of concentrated nitrous and ſulphuric acids, they immediately inflame, and leave a coal more or leſs inflated and voluminous. By employing nitric acid with caution, we may effect the exact analyſis of an oil; we convert it into oxalic acid. The ordinary muriatic acid produces very little effect upon fixed oil; the oxigenated muriatic acid thickens and whitens it like tallow or wax.

22. All the alkalis exert a more or leſs remarkable action upon the fixed oils; they all render it ſoluble, and reduce it to the ſaponaceous ſtate; the name of *ſoap* is even applied in a particular manner to this combination of a fixed oil with an alkali. The medicinal ſoap is made by triturating in a mortar of glaſs or marble, one part of cauſtic ley of pot-aſh, weighing at leaſt one half more than water, with

with two parts of oil of ſweet almonds. Trituration in the cold is ſufficient to effect this combination. With oils of inferior quality, and a cauſtic ley of ſoda, a little concentrated and well mixed, the common ſoap is prepared, which becomes ſolid in the courſe of time. Moſt commonly this combination is promoted by heat, in order to concentrate the ley; the liquid portion is afterwards ſeparated; when ley of pot-aſh is uſed only a ſoft ſoap is obtained. That which is termed *marble ſoap*, is made with crude ſoda, ſulphate of copper, cinnabar, &c. The moſt ordinary ſorts, which are termed *green* or black ſoaps, are manufactured with the marc of oil of olive, of nuts, of rape-ſeed, and the cauſtic alkalis treated by ebullition. The reader may conſult, for the economical practice of this art, the inſtruction publiſhed by Citizens Darcet and Pelletier.

23. Soap, properly ſo called, or the combination of a fixed oil, with cauſtic ſoda, is a white, ſolid, acrid and alkaline ſubſtance, very fuſible in the fire, abſorbing a very large quantity of water, which greatly increaſes its volume; loſing this volume and becoming very light by expoſure to dry air, or by a gentle fire, from which the alkali gradually ſeparates in the form of cryſtallized carbonate of ſoda by long expoſure to the air; decompoſable by fire, and yielding its oil, part liquid and part ſolid, by diſtillation; very ſoluble in water, with which it unites in all proportions; forming either

a thick liquid filled with white, and as it were ſilky filaments, when this ſolution is ſtrong and concentrated, or an almoſt tranſparent liquid, when the water contains but little of it; giving to this liquid, beſides a ſoft, and as it were greaſy feel, an acrid urinous taſte, a milky ſemi-tranſparency, the property of forming much lather, and affording a kind of foam, which eaſily retains the air, and the gaſes under thin and tenacious tegument, as is exemplified in the ſimple art of making what are called ſoap bubbles; decompoſable by the acids, which ſeparate from it the oil, thick and more or leſs approaching to the ſtate of tallow or wax. We ſee by all theſe firſt phenomena that belong to ſoap, that in the union of the oils with the alkalis by which it is formed, the fixed oil has abſorbed a more or leſs conſiderable portion of oxigen; and that it is on this account that the contact of the air influences the ſaponification; that ſoaps are made more quickly and of better quality with the moſt concreſcible oils, or thoſe which are moſt diſpoſed to concrete, or even with thoſe that have already become concrete, eſpecially with the fats, &c. that it is alſo by this more ſpeedy oxidation, favoured by the preſence of the alkalis, that the ſoaps become ſolid, and that concrete oil is ſeparated from them by the action of the acids, and even of fire.

24. True ſoap, or that prepared with ſoda, is alſo diſtinguiſhed by the property of being decompoſed by means of barites, ſtrontian, and

and lime. Its ſolution in water, mixed with that of theſe baſes, ſuddenly forms a precipitate in white inſoluble flakes, which when chemically examined, is found to be a compound of the concrete oil with the baſe employed. All the ſoluble ſalts of theſe ſame baſes, as alſo thoſe of magneſia, of glucine, of alumine, and of zircon, produce an inſoluble precipitate analogous to ſoap, in the ſolution of ſoap of ſoda. This is the reaſon why this ſaponaceous compound cannot diſſolve, but, on the contrary, aſſumes the form of curd, with waters charged with any earthy ſalts. A ſimilar phenomenon takes place with all the metallic ſolutions and ſalts. As ſoon as we pour theſe ſolutions into that of ſoap, precipitates are formed, which are compounds of the metallic oxides with the oil; theſe precipitates have different colours, according to the different oxides; their coloration is conſtant and fixed, according to Citizen Berthollet, who, in giving an account of theſe compounds under the appellation of *metallic ſoaps*, has propoſed them to be uſed in painting.

25. Ammonia alſo reduces the fixed oils to the ſaponaceous ſtate; but its more feeble attraction never brings them to the concrete ſtate, or favours their oxidation, as is done by the fixed alkalis: accordingly it never forms any thing more than ſaponaceous liquids, more or leſs opaque, though ſoluble in water, and capable of forming a lather, as alſo of taking out oily ſpots like the ſolid ſoaps. For the reſt, the ammoniacal ſoaps exhibit moſt of the properties of the ordinary ſoaps.

26. No

26. No ſalt acts in the cold, and really unites with the fixed oils. The ſulphates, with the aid of fire and a red heat, are decompoſed by the oils then reduced to the ſtate of hidrogen and carbon. The nitrates burn and decompoſe them at an elevated temperature. The muriate of ſoda is frequently employed for hardening ſoaps. The ſuper-oxigenated muriate of pot-aſh, triturated with a little fixed oil, and violently ſtruck, ſuddenly inflames and detonates.

27. Some metallic ſalts mixed with the oils are decompoſed and precipitated by theſe ſubſtances, which ſeparate and diſ-oxidate their metallic baſes. This is particularly obſerved to take place in the mixtures which are made for ſeveral emplaſtic compoſitions. But this effect has hitherto been but little examined, though it merits the attention of chemiſts.

28. The fixed oils unite artificially with mucilages and ſugar; by triturating them with theſe ſubſtances we render them white, opaque and more or leſs miſcible with water: this operation is frequently performed in the laboratories of pharmacy.

E. *Species.*

29. I HAVE already ſhown that the ſpecies of the fixed oils might be diſtinguiſhed by the aid of their chemical properties. I ought to add, that this method of diſtinction is ſo much the more eſſential and neceſſary, as the number of theſe vegetable productions is extremely conſiderable. Every country, every climate, according to the

differences

differences of the vegetables which are cultivated in them, has different oils appropriated to a multitude of domeftic and economical ufes. It would even be fuperfluous here to prefent the enumeration of all the different fpecies of oils that are extracted and employed in different places. I fhall therefore confine the enumeration which I propofe to give, to the principal fpecies known and employed, efpecially in Europe, and particularly in my own country.

30. I fhall here more particularly diftinguifh the fixed oils in common ufe into two genera. The firft fhall comprehend the *fat oils*, which have the character of becoming fixed more or lefs fpeedily by the action of the cold, of thickening but very flowly in the air, and of being converted by it into tallow or wax. Thefe oils have alfo the property of being lefs alterable by the acids than the others, of eafily forming foaps with the fixed alkalis, of being inflamed only by the nitric and the fulphuric acids combined, and of becoming more or lefs fpeedily rancid when kept in hot and moift places, in contact with the air. It is efpecially in thefe fat oils of the firft genus, that we find the mild principle of Scheele in the greateft abundance. This chemift difcovered that by combining the oil of fweet almonds, of olives, and of rapefeed with the oxide of lead, by the affiftance of heat, and adding a little water to the mixtures, there was feparated from thefe oils a fupernatant liquid, which furnifhed him, by evaporation, a matter

matter of the consistence of a syrup, which took fire by being strongly heated, of which one part was volatilized without burning in distillation, which afforded a light coal, which did not crystallize, and did not appear to be susceptible of fermentation. The nitric acid, distilled four times upon this mild principle, changed it into oxalic acid. These characters remarkably approach this substance to the mucilages, as I have already indicated, and I refer it to the mucous principle.

31. In this first genus of fixed and fat oils, I rank, especially, the oil of olives, the oil of sweet almonds, the oil of rape-seeds, or colza, and the oil of ben, the four species which are the best known and the most employed in France.

A. The oil of *olives* is the only known species that is extracted from the pulp of a fruit exterior to the kernel, or a species of husk. The olive is bruised by a mill-stone placed vertically and turning upon an horizontal plane; the paste produced by this operation is subjected to the action of a press which causes the virgin oil to run out of a greenish colour, and with a strong taste of the fruit. The marc or pulp is afterwards moistened with boiling water, and pressed anew, in order to obtain the ordinary oil. The unripe olive yields a bitter oil, and that which is too ripe yields a pasty one. If the mills are not kept very clean, they remain impregnated with a rancid oil, which gives bad

qualities

qualities to that which is afterwards fabricated in them. Olives that have been kept heaped together too long, and that have fermented, yield a ſtrong oil, which can be uſed only for making ſoap. The oil of olives congeals or cryſtallizes at 10 degrees below 0, and does not become rancid except after an expoſure, of ten years to the air. It is an aliment and condiment very much employed, and very uſeful in the Southern Departments of France.

B. The oil of *ſweet almonds* is extracted from almonds which are firſt violently ſhaken in a ſack of coarſe canvaſs, and roughly rubbed, in order to ſeparate from them the acrid powder which covers their epidermis. They are pounded in marble mortars; the paſte is afterwards ſubjected to the preſs, and the oil iſſues out a little greeniſh and turbid, and, like the oil of olives, depoſits a ſediment by repoſe.

C. Oil of *rape-ſeed*, and oil of colza, are the names given to thoſe which are extracted from the ſeeds of two ſpecies of cabbage, the firſt from the *braſſica napus*, and the ſecond from the *braſſica arvenſis*; this oil, which is very good, does not dry, is leſs fixable and leſs rancefcent than the two preceding; it is much prepared in Flanders.

D. The oil of ben is extracted from the kernels of ben, which is very abundant in Egypt and Arabia; it is void of ſmell, but very ſuſceptible of rancidity, ſo that it very quickly becomes acrid; it eaſily congeals. As it is inodorous

odorous, it is particularly appropriated to perfumery.

We may fubjoin to thefe four firft fpecies, the oil of beech-maft, that of grape-ftones, that of the feeds of the fun-flower, and that of feveral fpecies of cruciferous feeds, which are of a nature analogous to the preceding.

32. The fecond genus of fixed oils includes thofe which I call *drying*; their characters are that they dry in the air, at the fame time preferving their tranfparency, and without becoming a kind of tallow or wax. They do not become fixed, concreted, or cryftallized by the cold, nor become rancid fo eafily as the preceding, nor do they form foaps fo eafily with the alkalis, nor inflame by the contact of the nitric acid furcharged with nitrous gas, without the addition of fulphuric acid. They appear to contain lefs mucilage than the preceding: accordingly, the linfeed oil excepted, Scheele does not indicate them amongft thofe in which he fays he has found the mild principle. It is alfo very probable that they owe their particular nature to another order and another proportion of combination in their primitive principles.

33. I alfo rank four principal fpecies of fixed oils in the fecond genus of oils defignated by the epithet of *drying*: namely, oil of linfeed, oil of nuts, oil of poppies, and oil of hemp-feed.

A. The oil of linfeed is extracted, as I have faid, from the feeds of flax, either in the cold,

cold, and then with difficulty and in ſmall quantity; this is what is appropriated to medicinal uſes; or after having torrefied thoſe ſeeds in order to dry their mucilage, and facilitate the ſeparation of a larger quantity of oil: this, which is more or leſs roaſted, burned or reddiſh, has a taſte which indicates its origin, as well as the alteration which it has experienced. It is deſtined eſpecially for the arts, for painting, and for fat varniſhes. It has a very bad taſte; it burns ill, and thickens in the air, though ſlowly and with difficulty. In order to render it more drying it is boiled with a little oxide of lead or litharge, and it is then ſold by the name of boiled linſeed oil. It is in this ſtate that it is employed in the preparation of the fat lute of the chemiſts.

B. The oil of nuts is extracted from theſe kernels after a ſlight roaſting, or without the action of the fire. The latter, when prepared with care, is pretty good, and is uſed as food and condiment by a great number of the inhabitants of ſome of the Southern Departments of France. When it is extracted from old nuts, more or leſs rancid and roaſted, it has a very bad taſte, and can hardly be employed except for coarſe painting; it thickens and dries pretty quickly in the air.

C. The oil of poppies is ſeparated from the ſeeds of the poppy, which, on account of its beautiful flower, is called *oeillet* in the Northern departments of France, where it is cultivated

tivated in great abundance. This oil is very beautiful, very clear, confiderably drying, without any difagreeable fmell or tafte, when it is well prepared. It is frequently employed as a condiment, and it is often fold for oil of olives; the latter is even feldom fold without an addition of oil of poppies: this oil has no foporific property.

D. The oil of hemp is expreffed from the feeds of hemp; it has always a harfh difagreeable tafte, and it is never ufed as a condiment. It is very drying and very thick: it is ufed only for fome kinds of painting.

F. *Ufes.*

34. FIXED oil, in general, is a mild fubftance, and is ufed for nourifhment, or for the feafoning of food. Accordingly the feeds which contain it are the principal food of animals. It is ufed only as feafoning to the aliments which man prepares, the form of which it varies in a fingular manner; when alone it is not eafy of digeftion; accordingly it is fcarce ever employed in this feparated ftate, but mixed with different fubftances, and efpecially with the vegetable acids.

35. In medicine the fixed oils are employed as emollients, relaxants, and, for allaying pains and irritations, diminifhing the drynefs of coughs, deftroying the impreffions of acrid matters and poifons. Formerly much more ufe was

was made of them than is now done. It has been discovered, since the middle of the eighteenth century, that oily substances are frequently more prejudicial than salutary to health, that they load the stomach, aggravate fever, increase the disposition to putrescence, and at present it is only ill-informed persons who make a frequent use of them. They are generally administered with syrups; they are frequently prescribed triturated with gums, sugar and water, in the form of loches; they are employed in pharmacy in the preparation of a great number of chemical and pharmaceutical compound medicines, of ointments, plasters, oily balsams, medicinal soaps, liniments, &c.

36. The oils are employed for a great number of uses in the arts; they serve to preserve many substances which are covered with them, or kept immersed in them; for softening leather, and skins; for preparing fat varnish; for mixing the colours used in painting; for spreading on a number of bodies in order to render them smooth, soft, or flexible, and to defend them from the action of the water and the air; in the preparation of *mastics*; for affording light by their combustion in lamps; for favouring the effect and the motion of metallic machines; in the manufacture of soaps, &c. &c.

Article XII.

Of the Ninth of the immediate Materials of Vegetables; of the Tallow and the Wax of Plants.

A. *Situation.*

1. I HAVE enumerated amongſt the characteriſtic properties of the fixed oils, their power of thickening in the air, and of thus forming, by the abſorption of oxigen, a ſebacious or waxy matter. This character ſhows itſelf in all caſes where the fixed oils iſſue from the plants, and are ſpread out in the atmoſphere. As it is then in ſmall drops, more or leſs minute, that theſe liquids exſude from the plants, being expoſed by this diſpoſition to the contact of the air, they attract oxigen more or leſs ſpeedily, and become concrete, ſo as to become a kind of tallow or wax.

2. It is in this manner that a waxy or ſebaceous matter is formed upon the catkins of the poplar, of the elder, of the pine, upon the leaves of roſemary, of ſage, on the ſurface of the fruit of the *myrica cerifera*, of the *croton ſebiferum*, and of a multitude of other ſeeds or vegetable capſules. But the moſt abundant, the moſt common, or rather the moſt general of theſe formations of concrete oily ſubſtance, more or leſs waxy, is that which takes place in moſt plants at the extremity of their ſtamens, and

and on the external ſurface of the anthers with which they are terminated. This latter membranous organ, which has been compared with the teſticles of animals, preſents to the obſerver, at the moment of fecundation, a greeniſh or yellowiſh powder, granulated, fatty to the touch, which is very eaſily detached by the ſlighteſt motion or rubbing of the anthers. A great number of obſervations prove that it is of an oily or inflammable nature: the daughter of the celebrated Linnæus has even ſhown that, when reduced into vapour by the action of the ſun, this duſt of the antheræ, which however is not the real fecundating part, but only its reſervoir or vehicle, inflames at the approach of a combuſtible ſubſtance in the ſtate of ignition, and preſents the ſame phenomenon which is obſerved in the fraxinella.

3. Though Reaumur was not able to convert this powder into real wax by the different means which he has employed for this purpoſe; though the experiments which I myſelf have inſtituted upon the powder of the ſtamens of the male hemp, did not meet with the ſucceſs which I hoped, it cannot be doubted that it is from this pollen that the bees extract the ſubſtance with which they conſtruct their combs: after having collected and worked it into ſmall balls with the bruſhes with which Nature has furniſhed their paws, they carry it into the hive; they ſwallow it, reject it by the mouth, knead it with a humour that proceeds

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from their bodies, give it the softness and ductility which it must have in order that they may be able to work it in the construction of their combs; and whether this change in the pollen be owing to the heat of the hives, or proceeds from the mixture of an animal humor with which they cover it, or finally whether it be the consequence of a digestion, or any alteration produced by the action of their stomach, it is certain that the wax of the bees has no other origin than the pollen of the stamina of flowers, which it resembles in many of its properties.

Sometimes the vegetable concrete oil, tallow or wax, is found in the internal part of fruits or seeds, and seems then to owe its formation and its nature to a combination of oxigen in the interior of the vegetable texture itself. It is in this manner that the parenchyma of the seed of the *croton sebiferum*, and of several other vegetables, especially the seeds of the caca, of the nutmeg, of the coco, contain a substance analogous to butter or tallow. I have observed that several of these seeds present at their external surface a more or less thick layer of real wax, well dried, concrete and brittle, whilst their internal parenchyma is impregnated with a less concrete oil, or a kind of tallow, more fusible, more soft, and much less resembling wax, which proves that the contact of the air gives to the first a much more solid state, a more marked oxigenation.

B. *Extrac-*

B. *Extraction.*

5. This kind of wax or tallow cannot be extracted from the vegetable matters which contain it in the fame manner as is done with refpect to the more or lefs fluid fixed oils. The folid ftate of thefe bodies oppofes it; we are obliged to expofe them at firft to a degree of heat fufficient for foftening or melting thefe fubftances. At this temperature, which we communicate to the bruifed feeds, or to the fruits that are covered with it, we may frequently, by afterwards fubjecting them to the action of a prefs, caufe this matter to run out. It is in this manner that it is extracted in pharmacy from the kernels of the cacao, flightly torrefied, reduced into pafte, and afterwards preffed with more or lefs force.

6. A more commodious and furer means for obtaining this concrete oily fubftance is almoft always employed. The feeds or the intire fruits that contain it in a thin layer applied over their external furface, are boiled. The heat of ebullition fufes this concrete fubftance, and renders it very fluid; it then detaches itfelf from the integument to which it adhered, and collects in a liquid layer at the furface of the water. This is fuffered to cool, and it is afterwards feparated very eafily when it has become fixed in a folid plate at the furface of the water. This

This procefs is efpecially employed for obtaining the wax of the galé, and fometimes for collecting the butter of the cacao; it may be employed in general for all the vegetable matters at the furface of which this concrete oily juice is collected and thickened into a folid layer. When it is practifed with the catkins of the poplar, the alder, the birch, the fir, fmall quantities of a kind of wax or tallow are extracted.

7. In thofe cafes where the vegetable fruits or grains contain, as is particularly exemplified in the *croton febiferum*, two kinds of concrete oily juices, the one more folid and of a waxy nature at the furface, the other fofter and of a febaceous confiftence in the internal parenchyma; we may combine both the proceffes that have been indicated in order to obtain each of thefe bodies feparate. We firft boil them whole in water, which feparates the external wax; and when they are deprived of this they are bruifed and expreffed, after having heated them in order to extract from them the tallow. It appears that in China this two-fold practice is employed in order to obtain feparately the vegetable wax which is employed for making tapers for the opulent, and the tallow which is ufed for preparing a kind of candles deftined for thofe who cannot afford to purchafe the others. I have performed this experiment upon the feeds of the croton, and have obtained two matters very well diftinguifhed by the folidity

dity and the concrete ſtate of the firſt, as well as by the ſoftneſs, the greaſineſs and the fuſibility of the ſecond. It was in this manner I diſcovered that this differs alſo from the firſt by a very marked purgative property.

C. *Phyſical Properties.*

8. Though the concrete oils all reſemble each other in their conſiſtence, they have, however, neither the ſame texture nor the ſame ſolidity: ſome are mild, homogeneous, of a fine texture, and like butter as to their ſoftneſs and fuſibility; they are accordingly termed *vegetable butters*, as the butter of cacao, the queyamadoa, &c. others are of a granulated texture more or leſs cryſtalline, as the butter of coco, the tallow of croton. Laſtly, there are ſome of a firmer conſiſtence reſembling real wax, like that of the (galé,) the wax of the wax-tree of Louiſiana, &c. Some appear capable of aſſuming the lamellated form. The pollen of the ſtamens is in ſmall incoherent grains, and does not aſſume the concrete, ductile, dry, and uniformly ſolid ſtate of wax, till after it has been wrought by the bees.

9. The taſte, the ſmell, the colour, are alſo properties of this concrete oil that admit of much variation; it is ſometimes white, moſt frequently yellow or fawn colour, ſometimes brown or green, ſeldom red. Though the moſt of them

are

are infipid, fome are acrid, auftere, or more or lefs pungent. Some are inodorous and others have a perfume. It is true that the latter moft frequently owe this property to a portion of volatile oil which is more or lefs intimately and abundantly united with them, as we fee in the butter of the nutmeg, and in all thofe which proceed from aromatic fruits or feeds.

10. We alfo find the fame variation in the fufibility of thefe fubftances, from the extreme foftnefs of the butter of Galam, to the dry, brittle, and confequently lefs fufible ftate of the wax of galé, and that of Louifiana. This fufibility commences between twenty-five and thirty degrees of Reaumur's thermometer, and extends to above fixty, as we fee in wax, properly fo called, the pureft and moft valuable of thefe matters of vegetable origin.

D. *Chemical Properties.*

11. All the chemical properties of the butters and the waxes of plants, whilft they approach more or lefs to thofe of the fixed oils, prefent, however, differences which depend upon their concrete ftate, and the proportion of oxigen which thefe oily juices contain. This difference fhows itfelf at firft, both in their diftillations and in their combuftion. When we diftil them, we obtain water from them more eafily; they yield more febacic acid; they afford an oil fuffi-

fufficiently thick and concrefcible, which is called *butter of wax;* we extract from them at laft lefs hidrogen gas, but more carbonic acid. The cafe is the fame with their combuftion; they do not require fo much air in order to burn; they yield a whiter flame, lefs fmoke and carbon; they burn more uniformly and more eafily than the fixed oils. The ufe of candles and tapers evidently proves thefe firft facts. When gently heated, this body becomes intirely volatilized.

12. Moft of thefe concrete oily bodies which are coloured lofe this colour by degrees, which is deftroyed by the contact of the air and of the atmofpheric water. When they are expofed in fmall fragments or thin flips to the contact of the air, they lofe their colour and become white; this is what happens with wax when bleached, by leaving it upon the meadows and wetting it with water, whilft at the fame time it is expofed to the rays of the fun. This colouring part has been compared with that of filk.

13. Some combuftible bodies unite ftill more eafily with thefe febaceous and waxy matters, and frequently experience more alteration from them than from the fixed oils properly fo called. Sulphur and phofphorus unite with them by fufion. The metals that are eafily oxidable are burned by them more or lefs quickly. Citizen Berthollet has found that by melting wax upon copper filings, and fuffering it to remain upon

them for ſome time, this metal was much more ſpeedily converted by it into green oxide than it is by oil; and it is very evident that this effect depends upon the oxigen fixed in the wax.

14. It is for the ſame reaſon that the powerful acids exert ſcarce any action upon the concrete oils: as the fixed oils are altered by them only in conſequence of their attraction for oxigen; the oily juices that are ſaturated with it have no longer the ſame cauſe of alterability; accordingly we meet with much greater difficulty in attempting their analyſis by theſe burning bodies. The oxigenated muriatic acid which thickens the fixed oils, produces no ſuch effect upon theſe concrete oily juices, and only whitens thoſe whoſe colouring part is ſuſceptible of deſtruction by oxigen. It is in this manner that the green wax of Louiſiana is very quickly whitened by being merely immerſed and remaining for ſome hours in this acid.

15. The facility with which the alkalis unite with the tallows, the butters and the waxes of vegetables, confirms what I have ſaid above concerning ſaponification. It is evident that it is to the oxigenated ſtate of theſe concrete matters that they owe the property which they poſſeſs of combining and forming ſoaps with the cauſtic alkalis. The ſoap of wax and ſoda is termed *punic wax*, and is frequently employed as an encauſtic. Theſe combinations poſſeſs, beſides, all the

the properties of the beſt ſoaps, and may be employed with much ſucceſs for the ſame uſes. As ammonia renders the waxes likewiſe ſoluble and ſaponaceous; its volatility may hereafter prove of uſe in the arts, in which it ſhould be an object to apply wax in a thin layer.

16. All the chemical properties of theſe bodies prove, therefore, that they are a kind of oxides of fixed oils, and that they owe their origin to a fixation of oxigen in theſe oils, to a combination without combuſtion, between carbon, hidrogen, and oxigen. There is reaſon to believe, that the chemical art will at ſome future period be able to imitate ſuch a combination, by fixing oxigen in the fixed oils, by means of different proceſſes and thus conſiderably augmenting their value by their converſion into artificial tallows or waxes. The firſt trials that have been made in this kind of reſearch already afford the beſt hopes, and they only require to be followed with more perſeverance.

E. *Species.*

17. Undoubtedly we are as yet far from knowing all the concrete fixed oily ſubſtances, which the vegetables are capable of furniſhing; their number is certainly much more conſiderable than has been ſuppoſed; and if we would, or could depend upon the vague, uncertain, and frequently ſo little enlightened accounts of travellers,

travellers, it would be poſſible to preſent a pretty conſiderable liſt of them. But as it is impoſſible to eſtabliſh any thing exact upon the ſimple aſſertions of moſt of theſe men, who are too little inſtructed to have been able to give exact notions concerning all the products of which they ſpeak, I ſhall here content myſelf with indicating the principal and the beſt known ſpecies of this genus, amongſt thoſe which I have been able to ſubject to ſome experiments, or which able chemiſts have indicated.

18. In this view I ſhall here cite the twelve following ſpecies: the butters of cacao, of coco, of nutmeg, of Galam; the vegetable tallow called queyamadou, that of the *croton ſebiferum*, the wax of the galé, the pela of the Chineſe, the wax of Louiſiana, the wax of the catkins, of the birch, of the alder, and of the poplar, the leaves of roſemary and ſage; finally the pollen of the anthers, and wax, properly ſo called.

A. The butter of cacao is extracted from the paſte of the ſeeds of this plant, *theobroma cacao*, either by ſubjecting it to the preſs, after having expoſed it to the vapour of boiling water, or by boiling it in water. More than a third and even nearly half the quantity of this paſte is extracted from it, when the cacao is ſound and of good quality. At firſt it is a little fawn-coloured or yellowiſh; it is purified by melting it again in water. It is then white, of a mild taſte, ſlightly granulated in its fracture, very unctuous to the feel, fuſible between twenty-

eight

eight and thirty-five of Reaumur's ſcale. It is this concrete oil that gives to chocolate its mild and unctuous taſte; it is ſometimes the cauſe of the difficulty which certain ſtomachs experience in digeſting chocolate; it is much employed in pharmacy.

B. The *butter of coco*, is found in the fruit of the palm, named *cocoſnucifera;* its heated pulp is expreſſed: ſome naturaliſts ſay, that it is ſeparated from the milk of coco in the form of cream; it is found congealed and granulated in the oils of coco that are frequently ſent to Europe. It is employed as a condiment in countries where the palm abounds.

C. The *butter of nutmegs* is extracted from this ſeed, *myriſtica officinalis*, bruiſed, ſoftened with water, and ſubjected to the action of the preſs; it is ſufficiently ſolid, of an orange yellow colour, of a pleaſant and aromatic odour, which it owes to the portion of volatile oil that is combined with it. It has an acrid and ſtrong taſte, which is much diminiſhed by keeping it fuſed, by agitating it in a large quantity of water, and by heating it for ſome time.

D. There is brought from Senegal, and comes by the way of the commerce of the interior of Africa, an oily, concrete, ſoft and very fuſible juice, which is called *butter of Galam*, from the African town where it is taken in the way of exchange; it is yellowiſh, almoſt always rancid, and acrid. It is ſaid to be employed as a condiment in the country. The

tree,

tree, or the plant, which furnifhes it is not known.

E. The *Queyamadoa* is another fpecies of concrete butyriform juice, which comes from Cayenne and Guiana: the tree whofe fruit affords this butter, is called *virola febifera*, by Aublet; it is a myriftica. This kind of butter is faid to be employed both as condiment, and as a combuftible fubftance, in the country.

F. The *croton febiferum*, or *fapium cerriferum* of Brown, Jacquin, and Juffieu, produces in America, and in many other hot countries, fruits nearly round, the external tegument of which is covered with a layer of waxy matter, which is fufed with the aid of boiling water, and collects at the furface of this liquid, where it becomes fixed by cooling. I have already obferved that we may extract from the bruifed kernel another matter which is lefs hard and lefs dry, more fufible, more analogous to butter. Its fmell, which is fufficiently agreeable, induced fome young perfons who performed this experiment in my laboratory, to try it as a condiment with fpinach; it gave them all a more or lefs violent purging, attended with ftrong colic pains. It feems this depends upon the perifperma, which is always acrid and purgative in this family of plants.

G. The wax of the galé is extracted in abundance in China, and in many of the Eaftern countries, from the feeds of the *myrica cerifera*, and from one or two other fpecies ſpecies of myrica, called wax-trees. Its ſeeds, which are round, and of a bulk nearly ſimilar to that of the ſmalleſt coriander-ſeeds, are covered with a layer of white wax, which eaſily ſeparates from them by the action of boiling water, and ſwims upon the ſurface of this liquid where it becomes fixed by cooling. Fine tapers are made of it. We are alſo aſſured that after having extracted this external wax, which is very dry and very ſimilar to bees wax, the Chineſe obtain from the bruiſed ſeeds reduced into a paſte, another fat matter, more ſoft, more reſembling tallow, and which they employ in the fabrication of a kind of candles, which are cheaper than the tapers of the wax of the *galé*. Abundance of wax is extracted in North America from the ſame *myrica cerifera*.

H. There is known in China, by the name of *pela*, another kind of ceriform juice, ſolid, concrete, even brittle, of a very beautiful and very fine grain, with which the Chineſe fabricate the moſt highly eſteemed wax-works. We have hitherto no accurate knowledge concerning its origin. According to the report of the miſſionaries, we ſhould be led to believe that it is a wax wrought upon a tree by the inſects; but they add, that the ſpecies of worm which prepares it, contains it in its interior, and that it is extracted from the worm itſelf. Others ſay, that they are kinds of ſmall combs formed by the inſects upon the leaves of the tree, which are wrought in order to extract the pela from them.

them. Nothing poſitive is yet known concerning this ſubject.

I. We ought to be better acquainted with the valuable and important matter which is called *wax of Louiſiana, (myrtle wax)* and which in fact affords a wax as fine as bees-wax, the properties of which it would be very uſeful to ſtudy, and to increaſe its importation into France. This ſpecies of green, granulated, brittle, dry wax is extracted from the ſeeds of a tree which appears to be the ſame with the myrica cerifera, or a proximate ſpecies, but with reſpect to which there is ſtill much uncertainty. Neither is it known in what manner it is extracted, though it is very probable that it is by boiling in water. It is imported into Europe in large cakes of the weight of ſeveral kilogrammes, of a greyiſh or yellowiſh colour. I have ſeen it of four different caſts. It is bleached very quickly by expoſure to the air and dew; the oxigenated muriatic alſo quickly deprives it of its colour, and bleaches it completely. By fuſing it afterwards, we obtain a ſpecies of wax almoſt as fine as bees wax, and which may be employed for the ſame purpoſes. It is ſaid that the green colour proceeds from the copper which is added to it, or from the copper veſſels in which this wax is melted. There is reaſon to believe that the myrica cerifera might be naturalized in the ſouthern departments. The myrica galé of the country about Paris affords no wax: it is from its name that

that the appellation of *galé*, or *piment* has been given to that of the Chinefe.

K. The male catkin of the birch, of the alder, of the poplar, and of the pine, yield, according to feveral authors, by boiling them in water, a kind of whitifh wax, fufficiently folid, in very fmall quantity, and which has not yet been employed for any ufe, on account of its fcarcity. No exact experiments have been made, and nothing pofitive is known refpecting the properties of this oily juice, which perhaps is nothing more than a refin. I fhall apply the fame obfervation to the pretended wax, which is faid to exfude from the leaves of rofemary, of fage, and of feveral other labiated plants: if it had the relations, which it is fuppofed to have with that of the myrica cerifera, it is fcarcely poffible to conceive how fo remarkable a fact fhould hitherto have efcaped the very multiplied inveftigations that have been made refpecting thefe plants.

L. I have already announced that the pollen of the anthers is a fpecies of waxy matter not adhering, nor ductile, which feems to want a flight change in order to become real wax, a change which is produced in it by the ftomach of the bees. It has not yet been practicable to convert the pollen of the anthers into real wax by chemical proceffes; but experiments have not been fufficiently profecuted for this purpofe, and every fact announces that by continuing our refearches on this fubject, we ſhall obtain all the ſucceſs that can be wiſhed. It is known that the powder of the lycopodium, which has been erroneouſly conſidered as a reſin, is very inflammable, and kindles by the mere contact of a body in the ſtate of ignition. This powder appears to be exactly of the ſame nature as the fecundating pollen.

M. Wax, in ſome meaſure the laſt product of the concrete vegetable oils, the moſt ſolid, the moſt brittle, the drieſt, and the leaſt fuſible of theſe concrete inflammable bodies, the moſt oxigenated of all the oily oxides, is collected in the hives, in the interior of which the bees have depoſited it for conſtructing their cells, of a colour at firſt fawn or yellow, but is deprived of its colour, and bleached by expoſure to the air, after it has been melted into thin layers, and known in this ſtate by the name of virgin wax; it is the moſt employed, and moſt uſeful of theſe combuſtible ſubſtances. Its ſoftneſs, its ductility, its fuſibility, its looſe texture, its whiteneſs, even its preſervation, its brilliant combuſtion, its dryneſs, its purity, and inodorous quality render it of ineſtimable value for the purpoſes of life. We ſhall ſpeak of this ſubject in the ſubſequent ſection.

F. *Uſes.*

19. The numerous uſes in which theſe butters, tallows and waxes of plants are employed, are ſufficiently known. I have already elſewhere

elſewhere indicated a part of them, in the enumeration of the ſpecies: as condiments, as mild aliments, as matters proper for lubricating the ſurfaces of a great number of bodies, as combuſtibles proper for diffuſing a beautiful light, and diſpelling the obſcurity of long nights, theſe precious vegetable products render many ſervices to man. They are alſo employed for forming the ſolid maſs of ſtatues, for pouring into moulds, and repreſenting in relief all the objects whoſe image we wiſh to preſerve, or to imitate their forms. The ſculptor, the ſtatuary, and the model-maker find in them materials upon which they can exerciſe their talents. There are, therefore, few bodies more generally employed; and accordingly all countries have their wax, or their particular vegetable butters, and all nations are careful not to neglect, or deſtroy the plants which furniſh them.

20. Medicine has alſo derived very important advantages from them. The wax and the butter of cocoa anſwer a great number of purpoſes, and are applied to a ſeries of pharmaceutical works and preparations. Som-times they are employed as recipients, to baſes of other medicines; ſometimes they ſerve to give conſiſtence to remedies more or leſs compounded, ſuch as ointments and plaſters. Their mild or inſipid taſte, their unctuous and relaxing quality, and their emollient property, cauſe them alſo to be employed as primary and eſſen-

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tial remedies in a great number of cafes in which thefe virtues are indicated.

ARTICLE XIII.

Of the Tenth of the immediate Materials of Vegetables; of the Volatile Oil.

A. *Situation.*

1. THE name of *volatile oil*, in very marked oppofition to the former, is given to that oily juice, which when heated, like the fixed oil, rifes more or lefs fpeedily and eafily in vapour. It was formerly called *effence*, and *effential oil*, becaufe it was confidered as really determining the exiftence or the effence of the vegetable matters which furnifh it. Befides the characters of volatility, which diftinguifh it from the fixed oils, it has alfo a fmell more or lefs fragrant and aromatic; it is on account of this property that it was defignated by the names of *effence* and *effential oil*.

2. It is not with this genus of oils as with the preceding; they are not conftantly diftributed and infulated in the feeds or the fruits of the vegetables. Experience fhows that all the parts of vegetables are capable of contain-

ing them, and that by a very remarkable contraſt with the fixed oils, they are never met with in the interior of the ſeeds themſelves. This latter fact, which has not ſufficiently fixed the attention of chemiſts and naturaliſts, proves that the properties of theſe oils are intirely oppoſite to thoſe of the fixed oils, and that their uſes in nature and in the vegetable economy are altogether different; their burning acrimony would render them no leſs prejudicial to the embryos and the plantulæ, than the unctuous and nutritive mildneſs of the firſt renders them uſeful to theſe delicate beings. Nature has taken the ſame care to remove the volatile oils from the interior parts of the ſeeds, as ſhe has to convey the fixed oils thither; the latter are a real milk to the young plants; the former would act upon them as a deſtructive poiſon.

3. There are a multitude of odorous, aromatic roots, more or leſs acrid in their taſte, which contain volatile oil, but in ſuch ſmall cells, or in ſuch minute veſſels, that the eye cannot diſcern it in them, and that it cannot be extracted by mechanical means; but the ſmell, the inflammable property, and the more or leſs hot and burning taſte of theſe woody roots prove them to contain this vegetable principle. The principal examples of roots charged with volatile oil, are the avens or bennet, elecampane, white dittany, Florentine orris-root, &c.

4. A great number of woods, eſpecially the *ſantal*, very improperly called *ſandal*-wood in commerce,

commerce, and in the arts, the lignum Rhodium or rofe-wood, the pines, the firs, the larches, and moft trees of the hot climates, efpecially in India and America, contain more or lefs confiderable quantities of volatile oil, which is intimately and profoundly contained in them. The aromatic and pungent barks are alfo impregnated with them, efpecially thofe of cinnamon, of the caffia lignea, &c.

5. The leaves of all the labiated plants are filled with volatile oil, and frequently even the cellules which contain it are vifible or perceptible to the naked eye by the rugofities, the afperites, the tubercles which mark the furface. There are even fome, like thofe called (in French) on that account *mille-pertuis*, that prefent to the eye very numerous tranfparent points, which have been taken for holes, but are merely fmall cellules, covered only by the epidermis. All thefe oily leaves are diftinguifhable by their lively odour, which is particularly developed when we bruife them in the hands, and by the manner in which the vegetables which bear them quickly change the air of the atmofphere. Amongft the fpecies of plants with odoriferous leaves, are efpecially enumerated balm, the mints, efpecially pepper-mint, phlomis, origanum, rofemary, and many other labiated plants. The odorous leaves of the umbelliferous plants, and efpecially of parfley, chervil, fennel, and angelica, alfo afford volatile oil. For the reft the chemical character of this

this family is to contain volatile oil in every part. The leaves of the compofite plants, fuch efpecially as wormwood, and camomile, afford much of it; hypericum and rue are of the fame clafs.

6. There are fewer flowers capable of furnifhing it. We may however diftinguifh the florets, and femi-florets of the camomile, as well as of feveral fyngenefian plants, the petals of the lemon and orange trees, in which it is feen in tranfparent cavities. Many flowers contain it in their calixes, fuch as the rofe, the clove, lavender, thyme, and a great number of labiated plants; fometimes even we can obferve the veficles that ferve as refervoirs for it, like fmall tubercles, or ridges, or parts more tranfparent than the reft. In general we obferve that the oleiferous perianthufes are either flefhy like thofe of the rofe, or fquarrofe and ligneous, like thofe of the labiated plants.

7. Volatile oil is fometimes fixed in the fruits, and efpecially in their teguments. Vanilla, cardamoms, cubebs, pepper, the berries of the juniper, are of the firft order. Lemons, oranges, citrons, bergamots, and all the fruits of the genus *citrus*, contain it in their external coloured fkin, and in fmall cells, excavated in their zeft, which are eafily perceived on the outfide of thefe fruits, and which appear in the form of fmall cavities difperfed over its furface: here the quantity of this oil is fufficiently confiderable, and the refervoirs

which

which contain it are fufficiently full for it to be extracted by fimple preffure, as is proved even by the play of children when they fqueeze orange peel clofe to the flame of the candle, in which the volatile oil affords a flafh of fire and very white fparks, as it paffes through it.

8. Laftly, there are a multitude of feeds from which the volatile oil is extracted in confiderable abundance; but it is not contained in their interior, as I have already remarked; Nature has even taken many precautions in order to remove it from the embryo lodged between the cotyledons. On the outfide of thefe there is a tunic, frequently horn-like, fometimes double, in the duplicature of which the particles of volatile oil are lodged; fo that being fituated on the outfide of this hard and impenetrable integument, it cannot pafs through and reach the interior part. This admirable ftructure is efpecially obferved in the feeds of a great number of the umbelliferous plants, whofe ridgy furrowed, tuberculated furface is placed beneath thefe appendages of fmall drops of volatile oil. What has been faid of the nutmeg, which contains volatile oil in its interior fubftance, muft be underftood only of a particular fubftance which is not the pulp of the cotyledons itfelf, but a kind of perifperma, which has no communication with the embryo.

9. The quantity of volatile oil varies greatly in the parts of vegetables that contain it, according to the age and the foils which have produced them. Some plants yield more of this oil

oil when they are fresh; others, which are fewer in number, afford more of it when they are dry. We may see in the Elements of Pharmacy of Baumé, an useful notice concerning the preparations of this matter extracted from the principal plants in common use, in different states and in different years.

B. *Extraction.*

10. THERE are two general processes for obtaining volatile oil. When this principle is sufficiently abundant, fluid, and contained in vesicles, almost insulated and pure, so as to be capable of being separated from them by mechanical means, simple expression is then employed. It is in this manner that the volatile oil is extracted from the lemon, the citron, the bergamot and the orange; it is well known that by pressing the fresh peels of these fruits we cause this oil to shoot out in the liquid form. In the southern departments of France, and in Italy, these fresh peels are rasped, the oily cells are lacerated, the paste formed by the parenchyma impregnated with oil is pressed upon inclined plates of glass, the oil collects upon them in drops which unite, and run towards the bottom where they are collected; they are suffered to deposit a fine sediment by being kept at rest in close vessels, and thus are obtained what perfumers call essences extracted without heat.

11. Most of the oleophorous plants do not admit of this treatment, because they do not contain

contain the volatile oil ſo detached, ſo diſtributed, ſo fluid, and ſo abundant: all theſe and their parts which are dry are treated by diſtillation. After they have been macerated for ſome hours in water; they are put with the water into a copper alembic, which is filled about two thirds; a capital of tin provided with a refrigeratory is added, and luted with ſized paper to the cucurbit. The fire is urged to ebullition, after cold water has been put into the refrigeratory; a large quantity of the vapour of odorous water riſes charged with volatile oil, which it actually contains in ſolution, and accompanied with the portion of volatile oil which it cannot diſſolve on account of its abundance; both theſe products are received into a veſſel of glaſs of a particular form, which is called a Florentine receiver, becauſe it was firſt uſed at Florence. It is a conical veſſel having a tube a little above its bottom, the upper extremity of which reaches only a little below the aperture of the receiver, and which, being curved at this place towards the baſe, ſuffers the more abundant portion of water to run off, and permits the oil to collect in the upper part of the receiver; formerly a worm was employed in the diſtillation of the volatile oils, but it has been laid aſide, becauſe it was perceived that a portion was loſt, which attached itſelf to the ſides of the metallic tube.

12. The water which paſſes with the oil is white, turbid, and as it were milky, becauſe it contains a ſmall quantity of oil ſuſpended; but this

this liquor gradually clarifies, by depositing this oil, which rises to its surface and unites with that which passes immediately in drops. When this water has become clear, it is still charged with the odour of the plant, and it was formerly thought to be impregnated with a particular principle of the vegetable which Boerhaave called *Spiritus Rector*, and was designated by the name of *Aroma* in the methodical nomenclature; concerning the pretended existence of which I shall show that the chemists have committed a great error. This odorous water, which accompanies the volatile oil in its distillation, is nothing but a real solution of volatile oil in the water as I shall soon demonstrate. As a first proof I here mention the property which it has long been admitted to possess, of augmenting the quantity of oil that can be obtained by the distillation of a plant, when we distil it dry and scarcely odorous, with the aromatic water obtained from the same plant: this is always carefully practised in laboratories that are managed with proper care and attention.

13. Some different practices are followed in the distillation of the volatile oils, according to the dry, solid, or more or less hard nature, and according to the proportion of this principle which exists in the vegetable substance. The roots, the woods, the barks, the fruits, the dried plants, are macerated for a longer or shorter space of time in water, after they have been

been cut, chopped, rafped or pounded. This maceration continues from fome hours to fome days, according to the folidity or the drynefs of the vegetable matter. In order to raife the mixture of water and plants to a higher temperature, and to caufe a greater quantity of volatile oil to come over, chemifts have recommended a certain dofe of muriate of foda to be added, which by giving greater denfity to the water, caufes it to affume a higher temperature previous to its volatilization. The frefh plants in full vegetation are diftilled with lefs water, and do not require to be previoufly macerated, nor do they demand fo high a temperature in order to give out their volatile oil.

14. A procefs was formerly employed in the laboratories of pharmacy and perfumery, which has long fince been laid afide on account of its imperfection and the bad product which it afforded. The vegetable matter, generally dry, efpecially the clove, was bruifed and placed upon a piece of linen extended over the furface of a conical glafs almoft full of water; upon this linen and above the vegetable matter which it fupported, a plate of copper containing ignited coals was placed; the caloric difengaged from thefe coals penetrating the vegetable fubftance, fufed and feparated the oil which paffed through the linen, and fell into the glafs, where it was collected at the furface of the water. This operation was termed *diftillation per defcenfum*, on account of the direction which the fire placed above gave to the vapour; but it afforded a

brown

brown and partly burned oil, mixed with that which the ſtrongly torrefied vegetable matter yielded, and with coal; it had beſides the inconvenience of cauſing a loſs of the greater part of the volatile oil, which eſcaped between the linen and the bottom of the plate of copper.

15. As moſt of the volatile oils are intended for perfumery under the name of eſſences, and appropriated to the preparation of different fragrant matters, I muſt here ſubjoin a fourth proceſs which is not generally ranked in this order of chemical facts, becauſe it has been conſidered as belonging to the hiſtory of the aroma, the particular exiſtence of which I do not admit, for reaſons which I ſhall ſoon explain. There are ſome plants or flowers of an extremely pleaſant and agreeable odour, from which no volatile oil can be obtained by diſtillation, becauſe this principle is ſo delicate in them, ſo much attenuated, and ſo eaſy to be decompoſed, that the temperature requiſite for diſengaging it deſtroys it, alters it, and renders it fetid: ſuch are the tuberoſe, the narciſſus, the jonquil, the lily of the valley, the hyacinth and moſt of the ſo highly fragrant flowers of the liliaceous tribe. Such are alſo in other families of vegetables, the reſeda, the turnſole and ſome others. A method has been contrived for collecting, fixing, and diſſolving this very fugacious and decompoſable odorant principle, by incloſing theſe flowers in cotton impregnated with a fixed inodorous oil, and ſuffering them to macerate for ſome time at a mild temperature.

perature. The oil of ben is taken for this operation; alternate layers of cotton impregnated with it, and of flowers are placed over a water-bath; the laſt of the layers of flowers is covered with a thick layer of the oiled cotton; a tin lid is cloſed and well luted on; the veſſel is then plunged into a water-bath, the water of which is kept at thirty degrees of heat and upwards; here it is left for ſome hours, or even ſome days; it is then cooled, after which the layers of cotton are carefully taken out, and preſſed; the oil which flows out is charged with the odorous principle of the flowers, and forms a kind of artificial eſſence; and it is ſo true that it is to a volatile oil that this odour is owing, that by afterwards treating the perfumed oils with alcohol, we take from them all this odour, and in that manner prepare what were formerly termed ſpirituous eſſential waters, or ſpirituous aromatic waters.

C. *Phyſical Properties.*

16. Though volatile oil, to whatever plant it may belong, and however varied it may be in its properties, nevertheleſs always preſents ſome that are ſufficiently diſtinct and ſufficiently marked to be capable of being conſidered as characteriſtic of this genus of immediate materials; though we may particularly enumerate in this order their fragrance and their volatility, yet theſe properties have ſuch a number of differences that it is impoſſible to

deſcribe

defcribe them in a general manner, and it becomes indifpenfably neceffary to take a furvey of the principal varieties which they prefent, in order to obtain a competent notion of the whole genus.

17. I fhall begin with their odour. The utmoft ftretch of the imagination cannot comprehend the aftonifhing multiplicity of varieties and of differences that belong to this firft character. Not only each plant and every oil has its peculiar character, but it alfo varies in each of thefe products, by fhades which the organ of fmell can alone appreciate, according to a multitude of circumftances, the influence of which it is impoffible to point out though we can eafily recognize their exiftence. What is of the greateft importance to be well known in this refpect, is that there does not exift, as has hitherto been believed a particular principle independent of the oil itfelf, which was formerly confidered as the aroma or Spiritus Rector, which was faid to be difengaged from the volatile oil: it is the volatile oil intirely reduced into vapour, and acting in its totality upon the olfactory nerves.

18. The confiftence of volatile oils varies, but much lefs than their odour. There are four principal kinds of confiftence in thefe oils; fome are fluid in appearance, like water or thofe of lavender, of rue, of lemons, of bergamot, and of citron; this is efpecially obferved in the oils obtained by expreffion. Some are thick, and vifcid, as are in general thofe of the woods, the roots, the barks and the fruits of India and America.

America. Others congeal and aſſume a granulated or ſolid conſiſtence at temperatures more or leſs low, ſuch as thoſe of aniſeed, fennel, parſley, and balm; ſome of the latter are always concrete, like that of the roſe, which has the conſiſtence of a butter or fat. Laſtly, ſeveral are capable of cryſtallizing, and depoſiting in the midſt of the portion that has remained liquid, tranſparent polyhedra, more or leſs yellow, which are nothing elſe than pure oil; it appears, however, that this latter effect which takes place only in the courſe of time, and has been obſerved eſpecially in the oils of roſemary, and of lavender, depends upon a commencement of oxidation, as Citizen Vauquelin had ſuſpected. Sometimes theſe oily cryſtals have been confounded with camphor, which is eaſy to be diſtinguiſhed from them, as I intend to ſhow.

19. It muſt alſo be admitted that a great difference obtains in the colour of the volatile oils. There are ſome which are colourleſs or have only a ſlight lemon-colour, like that of aniſeed, and moſt of thoſe that are extracted without the action of fire from the ſkins of fruits. Moſt are of a more or leſs marked yellow, ſuch as that of the officinal lavender, that of the greater lavender, which is called oil of ſpike, *lavendula ſpica*, and a great number of others; ſome are of a deep yellow, red or brown colour, as the oils of cinnamon, of cloves, of Rhodium, &c.; ſeveral are blue, that of camomile, green, like that of parſley, of a greeniſh blue,

blue, like that of hypericum; ſome are obtained blue at the moment of their diſtillation, but afterwards become red by lapſe of time, as is obſerved in the oil diſtilled from galbanum, &c. In general the yellowiſh and reddiſh are the two predominant colours in the volatile oils, and it is always at one or other of theſe tinges that they arrive and remain.

20. The taſte of the volatile oils is almoſt conſtantly acrid, pungent, hot, and even burning; ſome, however, have only a very feeble taſte. Frequently thoſe vegetable ſubſtances that are very acrid and bitter, do not yield an oil that has this property, as is the caſe with pepper and with worm-wood. When we place a ſingle drop of volatile oil upon the tongue, it produces upon it the ſenſation of a very violent burning and irritation. This ſenſation frequently even propagates and extends itſelf into the throat, the oeſophagus, and as far as the ſtomach, by an impreſſion of heat and acrimony, which excites with delicate and nervous perſons, ſpaſms, borborygmi, eructations, nauſea, weakneſs, and ſickneſs. Frequently this ſcene, which is entirely owing to the nervous action, terminates in evacuations. Accordingly the phyſicians, who rank this matter amongſt the almoſt cauſtic and acrid ſubſtances, when it acts in the maſs, have conſidered it, when preſcribed only in a very ſmall proportion, and extended in a voluminous vehicle, as a ſtimulant, and more or leſs powerfully irritating. Its effect is ſpeedily propagated to organs far remote from the place

to which the volatile oil is applied: in this manner it quickly imparts to the urine a ſtrong ſmell, which is frequently agreeable, and reſembles that of the iris or violets. It is by a ſimilar principle that aſparagus appears to communicate to it an inſupportable fetor.

21. In general, the volatile oil has a ſpecific gravity inferior to that of water, and as is well known, ſwims upon the ſurface of this liquid. However, thoſe of the clove, of cinnamon, and of ſaſſafras ſink in water; but it is not to be concluded from hence, that the oils of exotic plants, thoſe of India eſpecially, are generally heavier than water, ſince thoſe of mace, of nutmegs, of pepper, of cubebs, of cardamom, are lighter than this liquid. In general the ſpecific gravity of the volatile oils that are lighter than water is to that of this liquid as 8697, 8938, 9910 to 10000. That of thoſe which are heavier on the other hand, : : 10363 or 10439 : 10000.

22. To this enunciation of characters, or phyſical properties, we muſt ſubjoin that of the adulterations or ſophiſtications which are too frequently practiſed upon theſe oils; it is almoſt always with the fixed inodorous oils or with oil of turpentine, the moſt common and the cheapeſt of theſe ſubſtances that the more coſtly volatile oils are diluted and their quantity increaſed. By rubbing a piece of fine paper which quickly becomes impregnated with it, we diſtinguiſh a volatile oil adulterated with a fixed oil, by the circumſtance that when the portion of

of the firſt has been volatilized, there remains upon the paper an oily ſpot, formed by the fixed oil, which is not volatilized in the ſame manner. As to thoſe that are mixed with oil of turpentine, they are diſtinguiſhed by the very characteriſtic odour of the latter, which remains for ſome time after the volatilization of the other. Mere friction in the hands is frequently ſufficient to diſtinguiſh both theſe ſophiſtications by the ſmell. It is more difficult to diſtinguiſh the mixtures of the volatile oils that reſemble one another in their ſmell, conſiſtence and colour; but theſe are more rare and leſs fraudulent. When they are mixed with alcohol, we may eaſily diſcover this fraud by throwing them into water, which produces a very abundant milk-white precipitate.

D. *Chemical Properties.*

23. After what has been ſhown in the two preceding articles concerning the chemical properties of the fixed oils, it is only neceſſary to compare the volatile oils with the former, and to inſiſt upon the differences that ſubſiſt between theſe two genera of bodies. It is evident, that the firſt difference which characterizes them, and which is expreſſed by their name, is that they muſt be infinitely more difficult to be decompoſed by the action of the fire than the fixed oils. They are reduced ſo quickly, and ſo eaſily into vapour, that it is almoſt impoſſible to effect their decompoſition

 in

in this manner. However by diftilling them very flowly with a gentle heat, after having fixed them to a certain degree by means of very fine fand or alumine, they afford water, carbonated hidrogen gas, carbonic acid gas, a portion of oil a little thickened, and they leave a coaly mark. By repeating this operation, the volatile oil is at length decompofed, though very flowly, and with great difficulty.

24. They are much more combuftible, they inflame in the cold by the mere contact of a body in ignition, or by the electric fpark; they diffufe, whilft burning, an abundant fmoke, and yield much foot; their flame is very ftrong and very white; the heat which they difengage very abundant, and they require more oxigen for their combuftion than the fixed oils, and afford more water amongft the products of their combuftion. This manifeftly proceeds from the large portion of hidrogen which they contain, and from the fmaller quantity of their carbon. On account of their greater combuftibility, the oil of lavender, or fpike, is ufed for the purpofe of lighting lamps for illuminations with greater difpatch, by firft impregnating their wicks with this oil.

25. When expofed to the cold air, they undergo another kind of alteration. Moft of them become coloured and thickened, they all emit a ftrong odour; they vitiate the air, and quickly render it deleterious to animals, as is proved by the paintings in which they are employed; they emit hidrogen which forms water,

water, of which we frequently find drops more or lefs perceptible at their furface, when they are kept in veffels not properly clofed. Some of them cryftallize; moft of them pafs into the refinous ftate, and then lofe the greateft part of their odour; which manifeftly depends upon the joint effect of the lofs of a portion of their hidrogen, and the augmentation of their carbon.

26. They combine fenfibly and eafily with water. It is fufficient to agitate them in this liquid in order to diffolve them. The fluid then contracts a ftrong fmell, and a flight acrid tafte; it is in this manner that I prepare the fragrant aromatic waters, which are nothing more than folutions of volatile oil in water, prepared by the action of fire, and diftillation.

27. They diffolve phofphorous and fulphur. The firft of thefe folutions, which is luminous in the dark, is very fetid, and affords phofphorated hidrogen gas by the action of fire, the fecond, which is very much coloured, and known by the name of *balfam of fulphur* in pharmacy, a name to which that of the oil with which it is prepared is added, as *terebinthinated, anifated,* &c. affords much fulphurated hidrogen gas by the action of heat. They do not act upon the metals, nor do they combine with their oxides like the fixed oils. In general they are lefs difpofed than thefe to form oily oxides, and when treated with oxigenated matter, whatever thefe matters may be, they tend rather

rather to be decompofed, and to fuffer their hidrogen and carbon to become infulated.

28. This is the reafon of the difference of the action which the acids exert upon the volatile oils, from that which they exert upon the fixed oils. In general the former are much more decompofable and alterable by thefe bodies. The concentrated fulphuric acid renders them brown and thick, by difengaging part of their hidrogen with effervefcence and heat; it converts a portion of them into water. What remains of the volatile oil after this action, is neither a refin, nor a bitumen, as has been believed; it is really the volatile oil reduced to coal, in part decompofed, and containing an acid. The nitric acid, charged with nitrous gas, inflames them immediately, converts a large part of them into water and carbonic acid, but leaves a voluminous and light coal; the fame acids, diluted with water, turn thefe oils white or yellow, and thicken them, but do not reduce them to the real faponaceous ftate, as has been pretended. This is only a flow decompofition, which tends to convert them into vegetable acids. The muriatic acid alters them but very little. The oxigenated muriatic acid whitens them, renders them partly concrete, or thickens them, and brings them nearer than the preceding to the refinous ftate.

29. The alkalis do not diffolve them but with much difficulty: hence the very long difcuffions amongft the chemifts concerning the

the ſoap propoſed by the alchemiſt Starkey The ſmall quantity of ſoap obtained by triturating concentrated cauſtic alkaline leys, with the volatile oils, and leaving them for ſome time together, is termed *ſavonule* in the methodical nomenclature, in order to indicate, that it is in fact a combination very ſlightly, or very little ſapanaceous. This weak combination between theſe matters, evidently depends upon the little tendency which a volatile oil has to abſorb oxigen without being decompoſed by it, or to form an oily oxide.

30. The ſalts exert no ſenſible action upon the volatile oils. The nitrates burn them with the aſſiſtance of heat. The ſuper-oxigenated muriate of pot-aſh inflames, and deſtroys them by percuſſion. The metallic ſalts and ſolutions are frequently decompoſed by the volatile oils, eſpecially when they are left for a long time in contact with theſe mixed combuſtible bodies. Thus a ſolution of gold, agitated with a volatil oil, and kept for a long time with it, precipitates grains or plates of gold: the oil acquires, in this caſe, the property of ſeparating in the cryſtalline, ſolid, and regular form, as has beei obſerved by Citizen Vauquelin.

31. Laſtly, volatile oil unites more or leſs eaſily with the different materials of vegetables tht have already been examined. Mucilage, ſugr, and even fecula, with the aid of a little heat, reneer them either ſoluble or capable of remaining fc a long time ſuſpended in water. It is in this mnner that we may communicate to this liquig or

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to ſeveral other bodies, the aromatic part of fruits with volatile oil, ſuch as the citron, the orange, &c. the peel is rubbed with ſugar, which abſorbs a portion of oil; and afterwards diſſolve this ſugar in water: this is what is named *oleo*, or *oleoſaccharum*. The volatile oils are very eaſily united, either with the fixed oils by ſimple agitation and mere mixture, or with the waxes and vegetable butters, by means of a gentle heat. The latter fix them in ſome meaſure, and thus form the unguents, or the fragrant ointments of the ancients. Nature preſents, ready formed, this union of an oily and butyraceous juice with a volatile oil, in the butter of nutmegs and in ſeveral other vegetables.

E. *Species.*

32. All that has been ſaid concerning the principal differences of the volatile oils, eſpecially as to their ſituation, of their extraction, and of their phyſical properties, might in fact be ſufficient to obviate the neceſſity of diſtinguiſhing ſpecies in this vegetable principle, and even to eſtabliſh a ſufficiently marked diſtinction amongſt them. I ſhall, therefore, content myſelf with preſenting a conciſe ſketch of the method which may be followed in order to divide the volatile oils into ſpecies, at the ſame time remarking, that I cannot attend to the object of treating ſimply of the numerous ſeries of

of oils, which are employed in the arts, but ſhall merely refer them in general to a certain number of principal ſpecies.

33. On comparing with each other the very numerous volatile oils, which are extracted from plants for the purpoſes of pharmacy or perfumery, I divide them into ſix principal genera, according to their ſenſible characters, their chemical properties, or their mixtures, and I deſignate theſe ſix genera by the denominations of *fugacious* oils, *light* oils, *viſcid* oils, *concrete* oils, *ceraceous* oils, and *camphorated* oils.

34. I term thoſe fugacious oils, which cannot be collected either by diſtillation, or by expreſſion; which cannot be obtained except by abſorbing them from the vegetables which contain them, and fixing them by means of fat oils. The principal ſpecies of this kind, which have hitherto been confounded with the ſpiritus rectors, or pretended aromas, are thoſe of the lily, of the tuberoſe, the narciſſus, of the hyacinth, of the convallaria, of the jaſmine, of the reſeda, and of the heliotrope.

35. The light oils of the ſecond genus are thoſe which are very liquid, almoſt colourleſs, extracted by the mere expreſſion of the cortices in which they are incloſed in very viſible veſicles. The beſt known ſpecies are the eſſences of lemon, of orange, of citron, of bergamot, &c. It is to be obſerved, that theſe are capable of paſſing into the two following ſtates, with the aſſiſtance of time and loſs of hidrogen.

 36. In

36. In the third genus I place the viſcid or thick volatile oils, generally of a brown colour. The preceding, when kept for a long time, arrive at this ſtate. This genus comprehends the oils of mace, of cardamoms, of pepper, and eſpecially the oils that are heavier than water, of ſaſſafras, of cloves, and of cinnamon.

37. To the fourth genus I refer the volatile oils, obtained like the preceding, by the action of fire and diſtillation, but which aſſume a concrete or cryſtalline form, either by cooling, or by a ſlow evaporation and cryſtallization. The principal ſpecies of the firſt are, the oil of parſley, of fennel, of aniſeed, of balm, of roſe, to the ſecond belong the oil of thyme, of marjoram, of mint, and undoubtedly a much greater number ſuſceptible of cryſtallization.

38. The fifth genus is formed by the volatile waxy oils which nature preſents, and which art extracts by preſſure, and their previous ſoftening by means of fire, in the concrete ſtate, united with butyraceous, or waxy oily matters. Hitherto, we know only the oil of nutmegs of this genus, but there undoubtedly exiſt many others in nature.

39. Laſtly, I appropriate the ſixth genus of volatile oils to thoſe which I term camphorated, becauſe they naturally hold in ſolution the volatile and inflammable ſubſtance, which ſhall be examined in the ſubſequent article, under the name of camphor. The oils of roſemary, of ſage, of lavender, of matricaria, of marjoram,

of

of pulſatilla, of the roots of zedoary, of valerian, &c. belong eſpecially to this genus.

Theſe diſtinctions, however, will be rectified in proportion as the obſervations upon theſe oils ſhall become more exact and more numerous.

F. *Uſes.*

40. It has been ſeen, by all the preceding details, that the volatile oils are uſeful for a great number of purpoſes. Beſides the medicinal properties which characterize them, and which cauſe them to be employed in many caſes as very active and very valuable remedies: beſides their very multiplied effects, and their frequent uſe in the form of aromatic waters; beſides their application as ſtimulants, antiſeptics, and external catheretics, they form the principal ingredient of perfumes. They conſtitute all the odours that were formerly called ſpiritus rectors or perfumes; it is not only in their primitive ſtate of eſſences that they are employed in perfumery; they are combined for that purpoſe with fixed oils, with mucilages, with fecula, with alcohol, with vinegar, with fats. They are added to the powders, and the kinds of plants that are uſed for filling the perfuming bags, the *pots pourris.* Their forms and modifications are varied in all poſſible ways.

They

They alſo enter into the compoſition of ſome fragrant ſubſtances for burning, or of aromatic paſtils.

They are mixed with a great number of liquors, in order to render them aromatic and agreeable, eſpecially the liquors uſed at table.

They are alſo employed as combuſtible bodies in ſome circumſtances.

They are uſed for preſerving dead bodies, and form part of the materials uſed in embalming.

Laſtly, They are ſometimes mixed with reſins and gum-reſins in the preparation of colours and pigments.

END OF THE SEVENTH VOLUME.

W. Flint, Printer,
Old Bailey.