

General Division of the Course.

- 1.st head — The Effects of heat & mixture on
Bodys & Chymical Apparatus
 - 2^d — Elementary Bodys —
 - 3 — Vegetable Substances
 - 4 — Animal Substances
-

Division of the first head.

- 1.st The more general Effects of heat on bodys
 - 2^d The more general Effects of mixture on bodys
 - 3 An account of Chymical Apparatus.
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1.st The more general Effects of heat on bodys
I wish I could give you some well ground'd Theory
to

to explain the nature & operations of heat which are
 very extensive, but from the imperfect knowledge
 we have of them, I fear that I am incapable of doing
 it. Lord Bacon first plann'd out to Chymists
 the great necessity of attending to facts & experiments,
 In his treatise on heat, he observes several of the Phe-
 nomena attending it & handles the subject in a curi-
 ous manner, he concludes at least heat is caus'd by
 motion, many facts favour'd this opinion, such as
 the heat generat'd by the friction of hard bodies, that
 a small piece of Iron plac'd upon an Anvil, may
 by hammering be made red hot, that wheel-axes
 are sometimes set on fire by rapid motion, that
 by the Collision of flint & steel where a small piece
 of steel is shook off which will set fire to Tinder, -
 S^r Isaac Newton supports this conjecture by
 sup.

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supposing that heat is caus'd by the vibrations
of the particles of Bodies & communicated by those
of a subtile medium to other bodies, this system
was generally follow'd by the English Philosophers
& called the Mechanical Philosophy. Another
opinion was that fire is a Body sui generis &
diffused every where that that is the vibration of this
subtile elastic fluid, The french Philosophers have
mostly adher'd to this system called the Chymical
Philosophy, but as both of these are involved in
obscurity & do not explain the nature of that, I
shall enter no further into such an useless at-
tempt, however if you should chose afterwards to
prosecute this study you may consult the works
of Lord Verulam, Mr. Boyle & Boerhaave's dissertation
on fire, I shall therefore proceed to lay before you
many of the effects that it produces on bodies.
the

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The first observation that offers itself is that we find
it impossible to make that remain in any simple
mass of matter setting aside inflammable substances
for any length of time, it has an irresistible tendency
to flow from a warmer into a colder body. If heated
Iron is laid on a stone the heat flows into the stone,
If the Iron is put into water, the heat flows into
it till the Equilibrium is restor'd & the water takes
an equal quantity of the fire, In this manner it
pierces the densest bodies, being only equal'd by the
Magnet, the first effect it produces upon bodies
is expansion, that is when any body receives
any quantity of heat, it increases its bulk,
& to this rule there are few exceptions, there are
only three forms under which matter appears to
us, the first comprehends solid bodies such as
Iron &c. the second unelastic bodies as water, oil,
spirit of wine &c. the third Elastic fluid bodies as
air

air - I shall now shew you the effects of that
expanding body belonging to these three forms,
First, I take a cylindrical piece of Iron as also
another piece with a hole in it the cylindrical
piece in its natural state, just passes thro
the hole, but when heated red hot it will not, a
certain proof of its having increased in breadth,
If the cylindrical piece is made to go length ways
between two prominences when cold, if heated as
before it will be found lengthways, hence we find
heat to increase it both in length & Breadth, &
if it is thrown hot into cold water it will again
resume its former size —

To prove the expansion of an unelastic fluid. I put
some spirit of wine into an oblong vessel marked
with degrees on the neck, this I put into a vessel
of hot water the spirit rises several degrees,
but if put into cold water the spirit contracts &

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& falls to its former height, an Experiment of the Expansion of an elastic fluid may be shown by taking a Bladder with a little Air in it and exposing it to the fire, when its bulk will be so increased as to burst the Bladder, but upon exposing it to cold Air it will again resume its former size — These Phenomena demonstrate that every kind of Body expands by heat & contracts by cold, for if I had immers'd the Iron in a mixture of Salt & snow, it would evidently have been more contracted than in its natural state, some bodies suffer greater Expansion than others — rarer & lighter bodies expanding more than heavier (and denser, but this proportion does not always follow the degree of Density or Tavity. — Metals expanding more than Glass, these effects of heat & Cold prove both useful & inconvenient; The
the

The hooper & wheel-right apply the expansion of Iron with advantage in putting Iron hoops on the Casks & rings on Carriage Wheels which when heated go on pretty easy, but being cooled with water they contract & squeeze the sides of the Cask or felines of the wheel together, sudden heat or Cold apply'd to brittle bodies is apt to make them Crack or Break which proves of considerable inconueniency in Chymistry & in Chymical processes where glass & cast Iron vessels are used, as either the sudden application or diminution of heat is apt to break them - This is somewhat remedied in glass vessels by having them made thin which gives them flexibility of a spherical form which receives the heat or Cold more equally and of an equal thickness to receive the heat in the same manner, Water suddenly swells in passing from a fluid to a condens'd state

and

and this with such force as to burst very strong
 vessels - Mr. Boyle mentions an experiment of
 this kind, he took a brass tube of three Inches dia-
 meter and took a plug newly fitted to it, which
 was put down upon water put into the tube,
 and press'd with a weight of 74 pounds, the whole
 was exposed to frost when the water freezing rais'd
 the weight - The Florentine Accademicians made many
 experiments upon this subject especially one with
 a hollow Brass globe which they fill'd with wa-
 ter & compress'd it by a strong screw being turn'd
 thro the globe into the water, upon freezing the
 water the globe was found too strong to burst
 upon which as much was taken off as that it
 might give way to the force of the freezing water
 when it burst the force found requisite was 27000
 pounds, & so immense is this expansive force that
 it has been known to burst a Cannon the water be-
 ing

ing closely confin'd in it & expos'd to frost, -
from the same cause proceeds the bursting of lead-
en pipes for the conveyance of water, the loosening
of stones after frost, & the decay of buildings which
is found very great where there is much rain or
frost, & it may be from this effect of frost that
it is of excellent use, fertilizing soils as it swells
the earth & loosens its particles by which means
a greater number of them are exposed to the roots of
Vegetables, several opinions has been advanced to
account for the expansion of water upon freezing
as water converted into Ice is never clear but in-
terspersed with several cavities, it has been thought
that Air insinuates itself into the water during
freezing making it more bulky & lighter, but this
opinion has been refuted by placing water under the
receiver of an Air pump & exhausting the air as
much as possible & then frozen, when the same
Cavities

Cavities were found as before, & instead of being heavier
 it floated on the Surface of the Water. M^r M^r
 Mairan found that the particles of water assume a
 different arrangement on freezing from what they
 had before, & that they formed themselves in specula
 crossing each other at an angle of 60 degrees which
 may be observ'd in a basin of water when they
 shoot in times from the Circumference to the centre
 & that the same thing may be observ'd in flakes of
 snow & from their specula crossing each other,
 Interstices wou'd happen & make the Ice lighter
 than water - from the Crystallization of salt into
 regular figures it was supposed that there was
 salts mix'd with the water which made it take
 the above form in freezing, but M^r Margraaf's
 Experiments show that snow water is the pure-
 est of any -

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M^r. Riccius on the subject of Iron, observes with much ingenuity that cast Iron melted, in passing to a Cold state expands, this effect is more sensible in Iron than any other metal on account of the stately texture of which it is composed, he observes that cold cast Iron thrown into the same metal melted swims on the surface, in this case the immediate expansion of Iron on congelating seems to agree with the water, but they differ in this that Iron never expands by cold afterwards, whereas Ice exposed to a greater degree of cold becomes more bulky; the whole may not be closely connected, from a particular arrangement which makes it lighter than before —

But to return to the subject of heat in general, while it expands an unelastic fluid as water, oil &c. it does it with an irresistible force which is proved by an experiment of the Florentine Academicians upon a

a hollow globe of Gold filled with water & compress-
 -ed with a violent force, but this compression could
 not be made without heating & expanding the
 water, which made its way thro' the pores of
 the Gold or other Cavities, & appeared on the exter-
 -nal surface in drops - But the conclusion drawn
 from this that water is incompressible is false,
 for certain experiments shew that water & Mercury
 if placed in a Vessel with stem nicely graduated &
 put under an exhausted receiver, will rise a little
 by the pressure of the Air being taken off, the least
 Degree of heat will cause a greater expansion -
 It may be observed as remarkable that the heat in-
 -creases the bulk, it causes no alteration in the
 weight of body as Boerhaave has demonstrated by
 several accurate experiments - W. Murrumbrook says
 that a Cube Inch of Iron heated loses one hundredth
 part of a grain & that the same quantity of Lead
 loses

loses four grains but that when cold they return
 to their former weight, but this experiment is
 liable to fallacy — For weighing the hot metal in
 the scale rarifies the air around it which may
 make the metal appear lighter, or the heat might
 expand the Beam which would make it false —
 When metals are exposed to a sufficient degree of
 fire & the free air admitted a Calx is formed &
 this is found to be heavier than the metal was
 before, thus 100 lb of lead calcined produces 110
 of calx, it was therefore thought that fire was a
 gravitating body & which during calcination
 had communicated this weight to the Lead —
 Misschenbroek is of this opinion, insisting that
 since fire increases the weight of Bodies whe-
 ther it is terrestrial or pure Celestial inheres in
 them & therefore has weight it self. Tho treated
 metals are found lighter than when cold yet
 this

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This is no argument against the gravity of fire
for by heat the bodies are expanded & by their
increase of bulk lose more specific gravity
than they acquire increase of weight by the
heat, Thus Iron when heated is almost the
same as when cold because it expands very
little, but Lead in 4 pounds lost 4 grains -
while 4 pounds of melted pewter only lost 2 gr.^{ns}
because the lead expands into a greater volume than
pewter & therefore loses more weight, but as long
as their bodies remain ~~from~~ masses or are restored
to them they expell the fire & return to their former
weight which does not hold after calcination -
But if heat was a ponderous body the above reason-
ing would be insufficient to account for their
Phenomena which I shall endeavour to explain
on different principles afterwards. —

As heat or cold increases or decreases the bulk of
bodies

Bodys we cannot say with propriety that any body has a particular specific gravity without determining the degree of heat which is now done by the help of Thermometers of which I shall now give you an account.

Thermometers

The invention of Thermometers tho obscure, is given to Durbel, who published a Treatise on them in the Year 1668, his Thermometers were simple & imperfect being a glass tube with a bulb blown on one end & the other being left open was insert'd into a fluid coloured with red by applying heat to the bulb the air contain'd in the glass was rarify'd & expell'd & on cooling was nearly fill'd with the fluid the part of the tube left unfill'd was graduated so that by the application of heat to the bulb the air was rarify'd & the degree of expansion shewn by the decent of the fluid in the tube
but

but as this Thermometer was liable to be affected
 by the alterations of the Atmosphere it would not
 be a proper measure for the different degrees of heat
 at different times, The Thermometer now in use
 was first contrived by Santorius a Italian Doct.
 He took a glass Tube blown as before & by expell-
 ing the Air he filled the Globe of it & part of the
 tube with coloured Spirits of Wine when it was
 immersed in snow or Ice then by heat he forced
 the liquor up to the top & sealed it hermetically.
 During the space from the degree of Cold to that of
 heat which raised it to the upper part - say to 100
 equal parts & these parted by fives or tens, this
 kind of Thermometer was thought of by Mr. Boyle
 much about the same time, & it was held in great
 repute, but still it had a great Defect which
 was that none agreed in shewing the same
 temperature being made at random, to remedy this they

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They were made to show the greatest Degree of heat
in Summer & Cold in Winter by keeping them one
Year but this was also found liable to great
inconveniency, The method now followed was
first pointed out by S^r Isaac Newton & Dr
Wallis in 1727. constructed several on this plan for
his own use. Dr Martin who has published
several curious & ingenious discoveries on heat
first show'd its advantages, as melted snow was
found to possess the same degree of cold, & to cool
bodies immersed into it to the same point, the Ther-
mometer to be made was first put into it and
the place marked where the spirit of wine, oil or
Mercury or whatever fluid was used stood at, &
from M^r Boyles hint that boiling water was
always of the same heat, the Thermometer was then
plung'd into water in this state & the point also

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marked where the fluid rose to, thus we have two certain points that may be got on any Thermometer that will always be the same, by dividing betwixt these & carrying the divisions both above the boiling point & below the freezing, we can ascertain the different degrees of heat or cold of various bodies as far as the Thermometers are made to exhibit, the heat of the human body in healthy persons being almost constantly the same we may have another fixed point on the Thermometer, which is got by putting it into the mouth & the degree to which it rises marked. This method of constructing Thermometers has many advantages as they may be made on the largest or smallest scale & are free from the error of the expansion of the glass but it is a question whether the increment of the fluid in bulk is equal in the equal additions of heat

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heat, as a pound weight may stretch a piece of Cat-
gut one Inch but another pound will not stretch
it an Inch more & still left will be the third
pound, the Question therefore is whether the scale
of of a Thermometer which is one of expansion is also
a Scale of the degrees of heat, or are equal degrees of
expansion made by equal degrees of heat, this
Doubt first occur'd to me when thinking on some
experiments upon a similiar Subject & has been
overlook'd by both Boerhaave & Martini. but on
looking into the Works of Boyle & Renaldini,
found that the had occur'd to them, & the latter has
propos'd an experiment to clear up the matter
but which is attend'd with more nicety than he
thought of, Boyle in speaking of this asks whether
a double degree of Cold will produce a double degree
of Condensation? An other Author proposes to solve
it

it by means of mixing cold & boiling water together
but this was never put in practice, Hally in the
Philosophical Transactions concludes that the degrees
of expansion are not in proportion to those of heat
but his experiments are not to be depended upon,
while S^r Isaac Newton in the same book says that
they are in proportion but this is only supposition
In a later period Dr Brooks Taylor has given an
account of an experiment to ascertain the expansi-
on caused by different degrees of heat & is the
same which occur'd to me before I knew of his Trea-
-tise, It consists in producing three certain tempe-
-ratures of heat which may be had without the
assistance of a Thermometer, If the second is a mean
between the other two, it should be indicated by
the fluid in the Thermometer rising or falling to
the middle point betwixt them this may be
done by taking an equal quantity of hot &
Cold Water in different vessels & noting their Tem-
-peratures

Temperatures given by the Thermometer, let these be
 suddenly mixed together & the ~~Temperature~~ Temperature taken
 which should be an Arithmetical mean of the two
 The experiment has often been performed & found to An-
 swer pretty exactly - But Dr. Irvine of Glasgow -
 has found that boiling Spirit of wine, and mercury
 heated to 600 of Fahrenheit ceases to expand regularly
 & proportionably, The great heat that mercury
 is Capable of enduring without rising in vapour
 gives it a Considerable advantage over ardent spirits
 or Oils, tho the oils especially Alum Lini expand
 pretty regularly & bear a considerable degree of heat
 but they are inferior to Mercury as they are apt
 to adhere to the sides of the tubes and give the degree
 of heat with less accuracy

In making the above experiment great attention is
 requisite as it is liable to some fallacy, because
 in pouring the hot water into the cold a quantity
 of

of heat is lost by the absorption of the vessel & on pouring cold water into the hot so much heat is gain'd.

by the heat of the vessel, this is to be guard against by two methods either by observing the difference of pouring ~~hot~~ water into the Cold & the Cold water into the hot & taking their mean, or by using vessels of such thinness as will have little effect on the Temperature of the water, It is of great consequence in Thermometers that the bore of the tube be every where equal as otherwise a quantity of mercury in one place may be greater or less in another place of the Tube, The Tubes are proved by filling a part of them suppose an Inch with mercury which being moved from one end to the other & frequently measured by a pair of Compasses, if it still retains the same length the Tube will be proper for a Thermometer but if found to vary, it ought not to be used. Thermometers are liable to another defect which is that they are slow in taking the Temperature of diff-

different bodies to which they are applied, the quantity of glass or other matter about pocket Thermometers is not favourable to their heating & cooling quickly as it often requires 6, 8 or 10 minutes to bring them to their Temperature which on many occasions we ^{shd} be oblig'd to know sooner, therefore those with the Degrees marked by a diamond on the stem are the most eligible, the limitation of Thermometers in shewing great degrees of heat & cold is another defect as we are oblig'd to have them made with different liquours for different purposes even mercury boils at 600° of Fahrenheit, & was frozen at Petersborow, therefore when we want to calculate the higher degrees of heat we must have recourse to Sr Isaac Newtons ingenious method which he informs us of in the Philosophical Transactions. He took a mass of red hot Iron out of the fire noting the time that he did it, & then exposed it to a stream of cold Air, from time to time he put upon it pieces of Tin, Lead & other metals & observ'd at what period

of

of time they ceased to be fluid when the Iron was
 considerably cooled he apply'd his Thermometer &
 found that it cool'd in a certain progression, by
 computing this back he found out at what degree
 the metals placed upon it melted, & the heat of the
 Iron itself red hot, taking it for granted that it
 had always cool'd in a progression similar to that
 which he had observ'd with the Thermometer, another
 imperfection of Thermometers is, that they dont show
 us how much heat any body contains or the pro-
 portion that the heat of one body bears to that of
 another which is owing to our ignorance of the
 first or last degrees of heat, our knowledge of these
 may be compar'd to a Chain whereof the two extremi-
 ties are conceal'd & only the intermediate links ex-
 posed to view. The numbers on the Scales of Thermo-
 meters only inform us of the Variations of heat
 between two certain points which are known
 but as Scales have been variously mark'd it has
 caus'd Considerable confusion in comparing the
 experiments made by one Thermometer with
 those

those performed by another, the greater part of them
 when first in use were made by those who had oc-
 casion for them & the numbers begun at different
 points as they thought proper, but the most of
 them may be now pretty well compared as Dr.
 Martin has given us a comparative scale of all
 those that have been invented, in his essays —
 The scale of Fahrenheit is most known the lowest
 point of which is that shewn by the greatest cold
 he could produce by a mixture of snow & salt. He
 then marked the point produced by the cold of
 melting snow & divided the space into 32 parts
 subtracting his scale regularly upwards he afterwards
 found that a still greater degree of cold than that
 of salt & snow might be produced, he therefore
 begun his scale at 0 & continued it downwards
 to express the degrees of greater cold. In consequence
 of the invention of thermometers our notions of heat
 are considerably enlarged, by their aid we know that
 there

There is no substance so cold but what may be made
 colder by the assistance of salt & snow mixed to-
 gether & consequently will lose a quantity of heat
 it possess'd before. We may therefore account heat a
 positive & Cold a Negative power as we have no
 just reason to think that the latter proceeds from
 a positive Cause. Some Philosophers have
 thought otherwise, & that cold as an active form
 froze water from its particles having little Hooks
 that seized the Globules of Water & condensed them
 Dr. Clarke thinks cold owing to subline particles
 in the air of such figures as to produce the common
 effects of it. The different effects that heat & cold
 have on our Sences are considered by some to be an
 an argument for absolute cold, some Degrees of heat
 giving us pleasant sensations, others uneasy ones, &
 these are called hot & cold, but it may be reply'd
 that the same water will feel often different ^{two}
 point of heat to both hands of the same person. ^{hence}

Hence cold & hot does not depend on any thing steady on the bodies themselves but upon the state of the Organs to which they are apply'd in common language most extremes have different terms given to them & which seems to be the origin of this dispute for we have no reason but to suppose that if ~~heat~~ were taken away we should have absolute cold & if cold were taken away we should ^{have} heat, therefore as we have greater appearance of a Cause of heat than of Cold I shall use the term Heat & by Cold only mean a Diminution of it —

In some Countries a very Just degree of Cold has been experienced, Fahrenheit by a mixture of strong aquafortis & snow produced a degree of Cold 32 below frost but some of the French Academicians who ventured within the arctic Circle found that the Thermometer fell to 33 below & they lived in Rooms that excluded the external air & when a little was admit'd it froze their breath to snow & their lungs on inspiration seem'd to be torn asunder, the Spirit

spirit of wine that was frozen was not much stronger than Brand & the Thermometer fell to 65° below frost which is as much under it as the animal heat is above it, In Siberia the more to the but far from the sea, the mercury has been known to fall 120° below \circ , a degree of Cold which destroys the parts of an animal as effectually as the heat of red hot Iron Professor Brown in Petersburg in 1760 found the coldness of the air to be 40° below \circ of Fahrenheit's scale & on mixing strong Nitrous acid with the snow that the mercury fell to 352° below \circ , when it became stationary & on the glass ^{being} broke the metal was congeald & took several strokes of a hammer to break it, he also congeald some mercury in a hollow tube & found it hollow on the top in the same manner as lead after being melted & cooled, The Thermometer is said to have fallen lower than 352° below \circ but we may observe that some deception might have taken place and that the degree of Cold was not so intense, for the ball of the Thermometer was often track'd which would make the Mercury

Mercury but it is difficult to immerse Bodies in
 in this fluid & with a considerable heat it is
 apt to evaporate & make its use expensive, &
 as sand answers the purpose as well in propri-
 furnaces we have no occasion to use it —

From the above reason we may explain why cups
 of water don't freeze in the Coldest winter, when
 the cold air rushes over the surface of the water
 a part is cooled & will sink while warmer water
 supplies its place from below, so that the
 whole heat of the water must be carried off before
 the water can freeze to the bottom which a Winters
 Cold may not be able to do - & hence the remark-
 able temperature of the air on the ocean & in Is-
 lands in winter in comparison of continents
 in the same Latitude, but the equal Distribution
 of heat does not seem to agree with the same
 Phenomena that occurs, when we ascend into the
 higher parts of the atmosphere ~~They~~ seem to
 increase in coldness as is found in the Pyramids also
 and

in several of which the Ice & snow are higher than the fluids & seem still to increase, hail showers are also another proof of the coldness that must sometimes prevail in the upper parts of the atmosphere, this distribution of heat has been explained in different ways, but these appearances may be sol'd by considering that as the sun is the general source of heat on this globe, & that his rays act but little on transparent bodies in comparison of what they do on opaque ones consequently they will have but little effect on such a medium as air when the sensible near the Earth's surface where densest it must be exceedingly trifling on the high regions of the atmosphere - This is exceedingly evident on applying a Burning glass upon Water in a glass which will hardly be affected, but if a piece of Wood is presented to the focus it is immediately burnt to a black coal, - we may observe too that in sunshine & other opaque bodies are sooner & more

be heated than those less so — Air is a fluid very different from water especially in its great compressibility whereby it becomes much denser on the Earth's surface than higher up where there is less pressure upon it. This weight seems to have a great effect in retaining heat in bodies, for those in vacuo lose their heat much sooner than expos'd to air, as may be seen in water which boils easier in vacuo than in the open air & also sooner on the top of a mountain at least — with less heat than at its foot — Franklin has given us some curious experiments on this subject — when the equilibrium of the Atmosphere is undisturbed it remains dense below & rarer in proportion to its height but on the production of great heat on the earth's surface by the reflection of the sun's rays or other means a quantity of air becomes rarify'd & buoy'd up in the heavier air, its place is immediately supply'd by the cir

The ambient air & when the heat has been con-
 siderable the rushing in of air on all sides will
 be so great as to produce a whirling wind —
 The different density of air at different heights
 is employed by miners to produce a circulation of
 air in these mines — when their level has gone
 some length it is necessary a current of fresh
 air be admitted, for this purpose they sink a shaft
 or perpendicular vent down to where they are work-
 ing as summer or winter has very little effect on
 air at any depth below ground, that in the mines
 is pretty nearly equal but in winter the exter-
 nal air at the level mouth being colder than
 that within it, it will be forced up the shaft
 & a current of air carried on, but in summer
 the air on the mouth of the level will be ra-
 rified & heated more than that in the mine,
 consequently the course of the current will be changed
 and the air will be driven out of the level mouth.

Dr

Spring and Autumn the air within & without -
 being often of an equal temperature a Stagnation of
 air will ensue & recourse must be had to fires
 to promote a Circulation of air -

The Ventilation of Chimneys also depends very
 much on the same cause, as the air in the vent
 being rarer below runs up and fresh air rushes
 in from below & supplies a continual circulation.
 From such ~~an~~ experiments & facts it is plain
 that unless fresh air is admitt'd to supply the
 place of rarify'd air it will stagnate from the
 pressure of the Atmosphere & be retain'd in the
 place where the rarification begun - & this may
 be deduced as a proof of the advantage of plant-
 ing round the higher part of Countries which
 preserve the air from too quick circulation and
 the heat is retained in it as in a green house
 to the great benefit of vegetation & moisture is not
 carried so quickly off which is of service in im-
 proved Countries in Dry Years, I shall now pro-
 ceed to the next general effect of heat which is Fluidity

Fluidity

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The next general effect of heat is fluidity wh^{ch} both experience & observation prove to be as universal as the former - we not only find that solid bodies by heat alone may be made fluid, but that those to whom fluidity seems essential owe this quality to the heat they contain, & when that is sufficiently diminished they become cold - There are indeed some bodies that conduce to fluidity, for by adding spirit of wine or salts to water it is found to retain its fluidity in a much stronger degree than before - But mixtures of bodies generally melt sooner than either of them separate as may be instanced in metals but this is only an increase of disposition to fluidity which depends on heat at least - There are some few instances where we have not ocular demonstration of the fluidity of bodies depending upon heat but there is the greatest reason to believe that only a proper degree of cold is requisite to make them solid & that those bodies are ^{only}

only more fusible than others the least degree
 of heat being sufficient to keep them in a flu-
 id state, of this kind is mercury which no na-
 tural cold can congeal & was there thought
 inscapable of freezing till Professor Browns
 experiments prov'd the contrary, that fluidity
 is a general effect of heat has been much dis-
 puted & particularly by Muschenbroek who
 adapting the common prejudices with respect
 to water supposes that fluidity is essential to it
 from the smoothness & globular figure of its
 particles & that its congelation depends on their
 being fixed by the admission of frigorific par-
 ticles. ~~proposed~~ with this opinion he has been
 misled in his experiments and reasoning on this
 subject, As he is an author of reputation I shall
 now consider the principal of these and point where
 in he seems to be wrong. 1st He says that water
 if preserved on perfect tranquility tho' exposed to
 an air greatly below the freezing point will re-
 -tain

Main its fluidity but if disturbed it will im-
 mediately freeze this is true & rather seems against
 his Theory than for it as such a sudden genera-
 tion of frigorific particles seems difficult to account
 for. I shall give an explanation of this afterwards
 2nd He observes that frost will continue till the
 Thermometer has risen to 36 or 41 but several cir-
 cumstances should be known in this case before
 a conclusion is drawn, the state of the air sometime
 exposition of the Thermometer on a wall or on
 wood projecting from a house or towards the North
 as any variations in these will affect the Thermo-
 meter differently, besides in many places the
 ground after long continued frosts will become
 much colder than the freezing point sometimes
 9 or 10 degrees, & when a thaw comes on suddenly
 it will affect the air & consequently the Thermo-
 meter will be raised before the ground is affect-
 ed

affected, but I shall mention some circumstances with regard to this afterwards

3^{rdly} That frost has happened when the Thermometer was above the freezing point & showers of rain & snow when below it. These instances are owing to the same cause as the last mentioned, for it cannot be said that water will freeze when cold is above the freezing point & vice versa

4th He has observed frequently in the months of March, April & even in June, that on mornings succeeding a very warm day there has been a hoar frost & Ice upon ditches, hence he supposes that absence of heat alone without the assistance of some refrigerating particles could not have produced such a degree of cold - but in such times it often happens that early in the night the wind turns to the North or East & may bring them a sufficient quantity of cold as well as at any other time of the year to produce such slight kinds of freezing.

which generally affect the dew that has fallen on
 the leaves of vegetables — 5^{thly} It freezes more
 in some Countries than in others of the same degree
 of Latitude, this usually depends on their distance
 from the Ocean, 6^{thly} The Ice produced on standing
 water is not in proportion to the absolute cold —
 I have observ'd that air has not so much power
 to carry away heat from still water as from
 that which is in agitation. 7^{thly} A Quantity of
 salt & snow being mixed in a vessel & the whole
 put on the fire if a glass of water is put into
 this it will freeze faster than if it had not
 been set on the fire — here he has allow'd himself
 to be imposed upon, the manner in which salt
 & snow act upon each other, I shall explain here-
 after. 8^{thly} Aquafortis mixed with water makes
 it hotter but it makes Ice colder. Muschenbroek
 thinks there must be some thing heterogeneous in
 the

the Ice to produce this cold, but I shall explain
this on a different Hypothesis

9. ^{thly} A wet cloth hanging out in the open air will
sometimes freeze when there is no appearance of Ice
on Water & when the Thermometer is above 32, I
shall shew that ^{this} depends entirely upon the evapora-
tion that is going on from the Cloth which when
the Thermometer stands at 33 or 34 may reduce
the Cold on the surface of the Cloth to the freezing
point.

10. ^{thly} Ice-Water will not molify the
more tender plants nor make Tea or Coffee till
boiled for a long time this I apprehend is a decep-
tion - 11. ^{thly} That all other bodies except water are
condensed by cold it is expanded, but this is not
true for Iron & Regulus of antimony also take a
different arrangement of particles & expand after
fusion, & if we suppose that frigorific particles enter
the water we must suppose them likewise entering
Iron & Regulus of antimony when red hot -
from

from the little weight of these argument & from what
 I shall offer you afterwards it will seem that flu-
 idity is not an essential quality of water, nor
 extraneous particles necessary to its congelation &
 only one of the general effects of heat, the only kinds
 of matter which have a reluctancy to become fluid
 are some earths & stones but this number is
 few & now rendered still fewer since the invention
 of burning glasses which have greatly enlarged our
 notions of the effects of heat, such bodies as resist
 fusion are very white & those that are of this colour
 reflect the rays of light & hence not so easily affect
 as black ones which absorb them, besides these
 bodies that do not melt by themselves will when
 mixed with others from which ^{we} may reasonably con-
 clude that they would melt if we would apply
 sufficient heat to them. It is mere Hypothesis to
 say that fluidity depends on the globular figure of
 particles as upon this supposition the particles of all
 fluid bodies should have the same figure & these change
when

Supposed produced by the fire itself as he got
the alkaly from the solution in fossile acids & concludes
that the same prevails in other vegetable matters.
However notwithstanding this alkaly we cannot help
considering it as an acid as it has many of their proper-
ties, In its natural state it has little attraction for
water requiring twenty four times its own weight
to dissolve it. It does not effervesce with an alkaly
when mixed in cold water. But when the water is
heated the tartar dissolves & unites readily & effervesces
with the alkaly, its other qualities I shall defer till
I come to the compound salts. These are the Prin-
cipal species of vegetable acids, there are indeed some
few which differ in appearance from them but only
in being compoundd of the qualities of both some
approaching more to the Acetous, others more to
that of the Tartar, thus the juice of Sorrel Crysta-
lized in its external appearance seems to be of the Tar-
ta

Tartareous kind, but it approaches the acetous -
acid in being very soluble in water - again Lemon
juice tho at first sight it appears to be of the acetous kind
yet still retains its acid tho exposed to Heat for a long
time & tho considerably diminished in bulk, in this
particular it resembles the Tartareous & is quite op-
posite to the Acetous ~

Sedative Salt ~

Of the origin of this salt we are not certain & we only
find it in borax which is brought from the East-Indies
& when separated from it we get it in crystals w^{ch}
at first appear like small flakes of snow or ra-
ther spermacett, when Heat is apply'd to this
salt put into a glass vessel with a strait neck
some of the salt sublimus & fixes on the top in
a fine light substance from which we might be
provoked to think it volatile but this is not the
case as what remains in the retort cannot be
made volatile by any degree of Heat, but while

warm

warm continues ductile like melted glass & the sublimed matter returned put on the same appearance when mixed with water it dissolves & being left to Crystallize resumes its first form, the reason of the sublimation is that as the Crystals contain a small portion of water, when it rises the steam carries up with it a small portion of the salt & when the water is dispersed no more sublimed it has but little attraction for water unless warm, when it dissolves in large quantity it requires near twenty times its weight of water to dissolve it, & may be separated by Crystallization - In its taste it is bitterish, it changes vegetable blues to a purple but has much less effect than either the Fossil Acid or Alkaly - It effervesces with alkaly & shows some attraction for inflammable substances it dissolves in spirit of wine & in burning tinges its flame of a green colour - I might have here mentioned some other Acids, as those got from Ants Urine, Amber &c. but
as

as they are connects with other objects of Chymistry -
not yet treated of I shall delay an acct. of them
till afterwards —

Compound Salts

Compound salts are produced from the combination of
the three Alkalys & six acids, we might be led to
conclude that the various mixtures of them would pro-
duce a great number of Compounds but we shall
find that Alkalys have no attraction for Alkalys nor
acids for acids, they may be mixed together without
much altering their quality, the only combination
then that we can form is Alkalys with Acids which
are found to unite only in a certain proportion &
with effervescence, the acid suffering no change
but only dispersed thro' the alkaly united with its
particles & may be yet separated from it again &
neither alkalys nor acids can mix with more than
one kind at a time, if a quantity of the solution of
alkaline salt in water be put in a glass vessel
and

A few drops of the nitrous acid added to it a violent effervescence ensues till the acid I suppose unites itself to a portion of the alkaline salt the remainder being in statu gaseo & ready to effervesce on the addition of more acid, & thus continues with the addition of the acid till the whole particles of the acid have joined themselves to those of the acid when the effervescence ceases & the alkaly or acid is said to be saturated & have then no attraction for more of each other, In performing this operation agitation is requisite to bring the particles of both within the spheres of their mutual attraction, otherways we may err in adding too much of either one or other, & consequently the ceasing of the effervescence is not a ~~Criterion~~ ^{Criterion} of saturation - We must therefore examine some of its properties, if either acid or sour it is not compleat, & if too much of the acid or alkaly it will tinge a vegetable blue to a red or green, which it will not if a perfect saturation.

The best way is to have some bibulous paper stained with morch violet Juice for the test of the Alkalis, & litmus for that of the acids, & by dipping a piece of it in the mixture now & then we may satisfy ourselves of the true point of saturation.

In some cases this nicely is not requisite as when we combine a Volatile Alkaly with an acid, when the volatile Alkaly should predominate as either in Evaporation or Crystallization. The Alkaly that is superfluous is carried off & dissipated; Tho' all the Compound salts we are to treat of are compound'd of an alkaly & an acid, yet we are not to consider them as taken in purely & join'd together as most of them ^{are} form'd by nature without assistance. Neutrals or Compound salts have less attraction for water than the simple ones - most of them Crystallize & have less acremony in acting upon Animal Vegetables or mineral substances, so that, the both acids

Acids & Alkaly in their separate state corrode & dissolve
these substances, yet when united they form a mild com-
pound & used as a medicine, their action by union being
repressed & this generally in proportion to the closeness
of their combination - If the Alkaly or acid before mixture
be volatile this property is also generally repress'd &
the compound becomes capable of bearing a strong red
Heat - Hence these salts are call'd *Salia mixta Salia Neu-
tri &c.* from the supposition of the one destroying the
effect of the other. From this view of the nine simple
salts viz. the three Alkalys & six Acids there will re-
-sult eighteen compounds which are few in comparison
of the number you'll meet with in Chymical authors,
But many of these are synonymous from their not
being acquainted sufficiently with the Principles of
their Art - I shall therefore reduce the variety of
compound salts into a Table where their compound-
ing ingredients may be seen by inspection placing
the several acids in the first line above & the three
alkalys

alkalys in the first column to the right & where these
 join the salts formed by their union will be found,
 Below, I shall insert the synonymous names that
 have been given to these compounds to prevent the
 ambiguities that might ensue from misunderstand-
 ing Authors who treat them as different substances.

Table of Compound Salts

	Vitriolic Acid ⊕	Nitrous Acid ⊕	Muriatic Acid ⊕	Acetous Acid ⊕	Tartarous Acid	Sedative Salt
Fossile Alkaly ⊕	Sal Glauberi	Nitrum Cubicum	Sal Commun.		Sal Rupillens	Borax
Vegetable Alkaly ⊕	Tartarus Vitriolatus	Nitrum	Sal Digestivus	Tartarus Regenerat.	Tartarus Tartarizot.	
Volatile Alkaly ⊕	Ammoniac Vitriolicus	Ammoniac Nitrosus	Sal Ammoniac	Ammoniac Vegetabilis		

Table

Table of Saline Synonyma

1 Fossile Alkaly	6 spur ^t . Aluminis	1 Sal Glauberi	1 Sal Digestivus
2 Nitrum	7 Acid Calcanthe	2 Sal catharticus	2 Sal Febusugus
	8 Acid universale	3 Sal mirabilis	3 Sal Marin. Tegen.
1 Vegetable Alkaly	9 Acid primo genium	1 Tartarus Vitrolatus	4 Sal marin Coagul
2 Sal absynthii	10 Acidum celsum	2 Sal poly chrestis	
3 Sal Tartari	11 Acidum vag. fossile	3 Nitrum Vitridatum	1 Tartar Regeneratus
4 Nitrum frsrum		4 Sal Emixum	2 Sal Diureticus
5 Cineres clavilati aqua solutum	1 Acidum Nitrosum	5 Sal Eduobus	3 Terra foliata Tartari
6 Oleum Tartari O. Deliquium	2 Spiritus Nitre		
	3 sp. Nitri Glauberi	1 Ammon. Vitrosicus	1 Ammon. Vegetab.
	4 Aqua forti	2 Ammon. secretus Glauberi	2 sp. mendoceri
7 Scurum tartari	1 Acetum	4 Nitrum cubicum	1 Sal Ruspellens
1 Alkali Volatate	2 Acetum distillatum	2 Nil. Quadrangul.	2 Sal poly chrest
2 Sal Ammon. Volatile	3 sp. Aceti	1 Nitrum	Ruspellens
3 Sal cornu corai	1 Acidum muriatic	2 Sal petre	3 Sal sugnetti
4 Sal Urinae aqua solutum	2 sp. Salis	1 Amm. Nitrous	
5 sp. Salis Ammon.	3 sp. Salis Glauberi	2 Nit sine Volatile	1 Tartar Tartar- -risat
6 sp. Cornu cervi	1 Tartarus	3 Nit Flammans	2 Tartar Solubilis
7 sp. Urina	2 Crystalli tartari	1 Sal communis	
1 Acidum Vitrolie	3 Cremo tartari	2 Sal gemma	
2 Oleum Vitriolicum	1 Sal sedativus	3 Sal maramus	
3 spiritus Vitrolie	2 Sal Nasoticus	4 Sal fontium	
4 Acidum sulphuris	Hambergi		
5 spiritus sulph. & Camph.			

In arranging these acids I have had regard to their elective attraction placing the Vitriolic acid first then the Nitrous, the marine acetic, acid of tartar & last of all the sedative salt. If these acids & Alkalis are combined the Compound salts formed by their Union may be again separated by Heat especially when the one is much more Volatile than the other But in general we must have recourse to elective attraction, Here when we want to separate one of the Ingredients an acid or Alkali is applied that has a stronger attraction for the one with which the required one is united, than it has ^{with the other}. If it were required to separate the marine acid from its alkaline Base I should add some of the Vitriolic or Nitrous acid which having a greater attraction for the fixed alkali than the Mariett acid it is set free, & thus any of the acids placed before the sedative salt would separate it from any of its combinations, & then before the acetic would disunite it the two first Alkalis which in the Table are not separated by a line having an equal attrac

Attraction for the acids will not decompose any compound of each other from an acid but they will separate the Volatile Alkaly from any of its combinations with acids. Thus Sal Ammoniac dissolv'd in water & mix'd with any of the fix'd alkalis will have the Volatile Alkaly set free - There is a seeming objection to the Order of this Table which is that the sedative salt is sometimes employ'd to dislodge the nitrous & Muriatic acids & unites with the fix'd alkaly, but this is only done by heat which would partly separate those more volatile acids alone, & when these are dispersed the sedative salt unites with the alkaly & renders the separation more compleat. I shall now proceed to consider the common properties of the compound Salts -

Glauber's salts

They are so named from the invention & is compound'd of the Vitriolic Acid & the Fossile Alkaly they have a pungent bitterish saline taste & so strong is the adhesion of

of their Ingredients that Heat cannot separate them
& it requires a great Degree of it to make them fluid, nei-
ther can the addition of any of the simple Salts produce
a disunion as their attraction for each other is the greatest
of any. It was long look'd upon as an impossible or at
least thought a very difficult process to separate them
Dr Stahl confound'd the Chymists by advancing -
that he knew a method of performing this in the hol-
-low of the Navel which set others about trying dif-
-ferent ways, by Stahl's method it was necessary to
convert the acid into sulphur by adding to it the
principle of Inflammability in Charcoal (Dust &c.
for which it has a particular attraction & greater
than for the fix'd Alkali, thus the separation may
be perform'd by double elective Attraction as by the
addition of the principle of Inflammability in the Char-
-coal a sulphur is form'd by it & the Vitriolic acid,

(and

and they form a Hepas sulphuris with the alkaly of the Glaubersatts by the addition of the acetous acid, it unites with the alkaly of the Hepas sulphuris & leaves the Sulphurous Vitriolic acid which may be purify'd by Inflammation, but this process is easier in speculation than practice for the acetous acid & the alkaly are so near an equal fixity as not to be separated by fire at best to leave the alkaly impure, the acid may be freed by the addition of some of the others but this only increases the difficulty so that this method is never put in practice to obtain either the alkaly or acid for use - Glaubersatts dissolve easily in ~~water~~ water & require 3 or 4 times their own weight of boiling water which when set by to cool throw down Crystals of 6 sides when the operation is well perform'd, they contain a great deal of water & on exposure to a dry air lose it & turn mealy on the outside which by some ignorant people is thought a sign of impurity whereas it is of contrary.

Des

Substances, the Air indeed contains a small quantity of it as we see often some collected round the mouths of Bottles containing volatile salts, & some acids when exposed to the Air seem to Attract it from thence & become Acute, it is got from putrifying animal substances, from Bones, Horns &c, & from being first got from the Horns of Harts was call'd Cornu cervi, but contains it in considerable quantity as also urine which has from thence its Detergent quality. Near Volcanos it is got in the form of a compound salt call'd Sal Ammoniac & the Alkali obtain'd from this seems the purest of any tho now chiefly got from the Horns & Bones of animals - Its general names are salt of urine salt of Hartshorn & volatile ammonia, when combin'd with water Chymists call it spirit, hence the names spirit of urine spirit of hartshorn & Spirits of sal Ammoniac.

ACIDS

There are a greater number of acids than alkalis, I shall therefore reduce them to the order in which they

seem to be in greatest purity & least combin'd with water the Fossile Acids shall be first consider'd and they are these in number

1st Vitriolic Acid

2 Nitrous Acid

3 Muriatic Acid

General properties of Acids

In treating of the general properties of acids I shall consider them in their strongest & most highly concentrated state on purpose to be more concise, the first is the most fixed not being volatile till heated up to 600 degrees of Fahrenheit's Thermometer at which mercury boils, while the other two becomes volatile with a much less degree of heat, so great is the attraction of acids for water that we never can obtain them in a solid form & they unite with a kind of violence or impetuosity and generate a considerable Heat when the acids are detat'd with water they may be partly separated again by distillation tho' the whole cannot be carried off this

is what is called concentration & a rification or
dephlegmation & ought to be considered as solid
salts in a fluid from dissolved in water, with Ice
or snow they produce a degree of Cold greater than
either had before which has been thought ex-
traordinary but from what has been said on
the Liquification of Ice this may be very easi-
ly explained, it has been said that the
Vitriolic acid with Ice does not produce Cold
but rather Heat, this however must be a
Deception or caused by the addition of too much
acid as if a larger quantity is applied than
suffices to Liquify the Ice, Heat will be pro-
duced, the Acids have the common property of
changing the colour of vegetable Blue as
Syrup of Violets or infusion of roses &c to a red
or scarlet colour by the addition of an alkaly
this red is destroyed & the green takes place -
which may be alternately destroyed & recovered
by the application of first the one & then the
other.

Acids unite with alkalis with a considerable effervescence, as also with limestone marble & other absorbent earths they produce the same Phenomenon with metallic bodies with which they unite &c. Acids in their most concentrated state are highly corrosive & taken Internally in this state are certain portion considering animal substances as much as a burning coal would, but when sufficiently diluted they are cooling agreeable & wholesome, they are used for preventing fermentation, & also in Bleaching, to the taste they are sour & disagreeably rough.

& Vitriolic Acid

Vitriolic Acid is so call'd from Vitriol or Compas which yields it by distillation over a strong fire when pure it is colourless and transparent & very heavy its specific gravity to water as 17 or 18 to 10 on this account it has the sluggish appearance of oil & hence call'd oil of Vitriol tho' destitute of the properties of oily fluids. The salt it contains is more
fixed

fixed than water & emits no smell, it has
a strong attraction for water & a violent heat is
produced by their commixture & if exposed in a
vessel to damp air it imbibes a great quantity
of the moisture, when mixed with boiling wa-
ter a great effervescence & additional heat ensues
& the water is dissipated quickly - some Bleachers
imagine that it cannot be eternally united
with water unless the latter is boiling - but when
this is done the acid & hot water are scattered a-
bout spoiling the Linnen that is next it - when
diluted with water the mixture becomes milky &
by standing a calcareous earthy substance is de-
posited united with the acid which gets the
name of a selenite salt. The more the mixture is
cooled, the more apt it is to let fall this powder
To have the acid pure & free from it, it must be
redistilled in close vessels what arises first is
almost pure water increasing its acidity as the

operation increases till at last what arises is equally
with what remains in the retort then the
concentration can be carried no further by repeated
Distillations this acid may be made a little strong-
er & sometimes deposit Crystal but this I
imagine is owing to some impurity in the acid. The
Vitreous Acid has a very great attraction for the
principle of Inflammability & bodies that contain
it in considerable quantity if not fettered with
too much other matter. Thus when put into
a glass with common Florence oil they unite with
Heat & Effervescence, the mixture acquiring a thick
consistence & forming a substance like Tar. But
if added to the oil of Turpentine which contains the
principle of Inflammability in a more loose & unfet-
tered state it produces a more violent Heat & evolution
emitting a quantity of fumes tho' the oil requires a
considerable degree of Heat to make it boil. The
result of this mixture is a very thick substance

of a black colour & fatid smell - This accounts for the dark dusky appearance that the Vitriolic acid acquires on being kept in a negligent manner, as the least dust of animal or vegetable matter is sufficient to produce the Effect - it may however be ~~still~~ ~~separated~~ separated by applying a small degree of heat these matters rising & the Vitriolic acid left pure, but if the quantity of the Inflammable substance is more considerable in any body, it unites with it & undergoes greater changes from its connection with this acid as we see in the case of Brimstone, as when we take a body which has the acid in a dry state as alum where it is combin'd with earth & add to this the Principle of Inflammability as in Theriacal Dust &c. or with oils, in both these cases the acid rises in a Volatile form & like oil but considerably changing in consistency & colour & concretes in the necks of the retort in a matter much resembling sulphur that

that the nature of Sulphur is from the combination of the Vitriolic acid with the principle of Inflammability, appears from many Instances, for if we set Sulphur on fire what arises when condensed is found to be Vitriolic acid & no ashes or soot remains, & the Principle of inflammability left freely off, the combination of the latter with the volatile acid has a surprising effect in changing it from a corrosive & acrimonious to a mild & harmless state & which may be taken without danger in considerable quantity - its attraction for water is now destroyed & also for other bodies with which in its separate state it was disposed to act upon we shall find this often to happen in Chemistry & that the activity of Bodies in their simple state is much greater than what it would be when united with others - Sulphur however unites with alkaly very readily as may be shewn by putting some alkaly into a vessel & some Sulphur in powder as it is necessary that one or both of them be flu-
-id

fluid in order to have them unite we may either effect
this pouring boiling water on them or put them
dry together & expose them to a gentle heat when
they will unite with an exhibition & emit an ex-
tremely nauseous, smell the compound formed is call-
ed *Hepar sulphureum* from its colour resembling the
liver of some animal. The Sulphur itself has no
attraction for water yet with the Alkaly it acquires
one so great as to attract moisture from the air &
become humid on being exposed to it, when mix-
ed with water it acquires a yellow or redish colour
Sulphur may also be combined with *v. Vol. Alk.*
but does not emit such a disagreeable smell as when
united with the fixed alkaly, the process shall be
mentioned when the inflammable bodies are treated
of - to separate the Vitriolic Acid from the Sulphur.
There are several methods used, there is one menti-
oned in the Dispensatory which is by inflammation
but very little is to be got in this way as greatest
part of it rises in a suffocating vapour which can-
not

cannot be condensed the reason of this is that the sub-
-stance is but imperfectly decomposed and retains the
acid which rises along with its parts, some have
a particular method of decomposing the Sulphur
by inflammation by means of which they get a
great quantity of the acid but the process is kept
a secret from interested views

Origin of the Vitriolic acid

Some Chymists have supposed that this acid is diffu-
-sed thro the air & every thing else, & that on exposing
fix'd alkalis to the influence of the Atmosphere
they become neutrals, but the experiments made
to prove this are related in such a manner as
shew they are not to be depend'd upon, besides many
Experiments made by Boyle & Margraaf give us
reason to conclude that there is not the smallest
quantity of it to be got from the air nor from
rain or snow, whence it is probable that it
would have been got if any such acid had been
in the atmosphere, its principal source is
from