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Fermentation

MARCET

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Introduction.

In selecting Fermentation for the subject of this dissertation I could not flatter myself of throwing upon it a new light or of answering any of those interesting questions which have to this day perplexed the most celebrated Chemists. I have therefore merely endeavoured to collect such documents on that interesting subject as may lead to a complete understanding of its various phenomena & to a knowledge of the circumstances closely connected with them.

After we have related the facts with which we are acquainted in regard to Fermentation I have deemed it necessary to mention the various theories to which chemists have had recourse in order to explain them.

It has occurred to me that a sketch of the history of Fermentation would be ~~deemed~~ interesting & availing myself of the excellent treatise of Höfer on the history of Chemical science & of the writings of the leading Chemists in the beginning of the present Century, I have endeavoured to trace the history of the different facts & phenomena connected with my subject. I regret that my anxiety to fulfil completely this task has caused me to insist, perhaps too minutely on certain points, which may appear to have unnecessarily lengthened this dissertation but after having studied the subject I restricted myself within the narrowest bounds

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Further, he observes, that the Jews on leaving Egypt ate unleavened bread, baked, under ashes, for their departure had been hastened by the Egyptians to such a degree that they had not found time to mix leaven with the paste (Exod XIII 39th.

It appears that in the earliest periods of history, the paste for making bread, was only prepared just before the bread was baked; sometimes this paste was prepared with flour & water which was afterwards boiled with meat; to this the Romans gave the name of "Palmentum" or "Palmentarium"

When the Canary Islands were discovered, the mode of making bread was completely unknown to the inhabitants, they ate flour simply boiled with meat or butter.

The discovery of fermentation was probably accidental; people must have been much astonished on observing for the first time that the addition of sour paste to fresh flour, caused it to swell, & diminish in weight, acquire an agreeable flavour, and a more digestible nature. Pliny observes as follows in regard to the history of yeast:

" Yeast "fermentum" is now prepared with flour,
" it is made into a paste, (not salted) which is boiled
" & afterwards left aside until it has become sour;

" frequently the paste is not boiled, but some of the
" flour used the day before is kept for the purpose
" of making yeast. It is therefore evident that
" fermentation is produced by a sour element (naturam
" acori fermentari). Fermented bread is more healthy
" than the unfermented.

The same author observes, that ferment was prepared before his time, during the vintage, by mixing millet flour with the juice of white grapes (Musto Albo), ... The paste thus formed was moulded into pieces, which were afterwards dried in the sun; when wanted, they were mashed in water with dry flour & mixed with paste. —— The Greeks believed that 8oz of yeast were sufficient for a bushel of flour, and it is said that bread thus prepared was of excellent quality.

But sour paste was not the only substance used to cause paste to ferment, for yeast of beer, was employed a long time previously by the Gauls & Spaniards, and indeed in every country where beer was made.

It was the yeast from beer which the Romans called (Spuma concreta) & they believed the superior quality of the bread made by the Gauls was owing to this circum=stance. It appears that in the remotest periods of history, the agreeable flavour of the grape induced men to express its juice and collect it in

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wooden casks. Thus the art of making wine is in Egypt and in those parts of Asia where the vine grew of very ancient origin.
It was Osirus, who according to the Egyptian tradition first taught men to cultivate the vineyard and to make wine; another tradition ascribes the discovery to Noah & Bacchus.
The most ancient sacrifices offered to the Deity were composed of bread & wine.
The use of beer is also of very remote origin; it was probably at first but a mere infusion of ~~hops~~ barley (tisane) and was used under this form as a drink, by a considerable part of the population of Egypt.
The Spaniards & Gauls were acquainted with beer from an immemorial period, and Tacitus says that the Germans used a beverage prepared with barley & converted by corruption (fermentation) into a kind of wine (Ex hordeo factus et in quamdam similitudinem vin
The beer of the Germans was therefore evidently fermented
The use of hops in brewing is of a recent date which explains why the beer of the ancients easily turned sour, that is, underwent the acetous fermentation.
They were certainly not aware that during the fermentation of the juice of grapes & the must of barley, the saccharine principle was converted into alcohol by the action of a

ferment, they appear however to have been well acquainted with the fact that after a time, must lost its sweet taste, and acquired intoxicating properties.

Brandy, (of which the discovery) is simultaneous with distillation, is of more recent origin although the ancients made use of beverages containing it

The knowledge of wine beer supposes, that of vinegar, for the two former exposed to the action of air & heat become sour spontaneously, producing Acetic Acid,

The Ancients were acquainted with Vinegar but did not comprehend the mode of its production.

Vinegar was not only used to dress Vegetables ([illegible]) but diluted with water, it was considered to be a wholesome beverage (Numbers VI 3rd). It may here be observed, that as in many other instances, the Etymology of a word tacitly explains the notion it conveys. Thus in Hebrew language <u>Khomets</u> means at the same time vinegar and ferment, thus indicating that vinegar is a product of fermentation

Moreover the word (יין) <u>yine</u> comes from the verb (יין) to cause to effervesce or to rise, alluding to the must which rises during the disengagement of Carbonic Acid and its conversion into Alcohol.

The word <u>yine</u> signifies properly, product of fermentation, is very nearly the same in Phoenician in Syriac, Arabic

in Coptic & Armenian. The Greek term <u>οινος</u> and the Latin <u>vinum</u> are evidently derived from the same root for <u>οινος</u> was probably pronounced <u>ινος</u> as at present in modern Greek and with the mere substitution of νι to ι the Latin word vinum is obtained
The German word (<u>wine</u>) the Italian vino and the French (vin) have all a similar origin.
The Grape was not the only fruit that yielded wine to the ancients, the juice of the palm & of other vegetables was employed in very remote period for the preparation of fermented liquors. Herodotus was well acquainted with the Palm wine of the Assyrians.

The Greeks & Romans from all we hear, appear to have carried the art of making wine to a considerable degree of perfection. The wine (<u>aigleucos</u>) was a species of Champagne, which was kept at a low temperature to prevent its complete fermentation.

The Greeks & Romans were therefore evidently acquainted with the important law, that fermentation cannot take place under a certain degree of temperature. Pliny tells us that grapes in order to be preserved, were inclosed in glass bottles, the stalks of the bunches having previously been dipped into pitch. It is not impossible that the bottles being well stopped were rendered impervious to the air and the pitch containing a great deal of Carbon might then decompose the air enclosed in the bottles, it seizing the oxygen. The grapes deprived of this important element would thus be no longer liable to any species of fermentation & might be preserved for a considerable time.

To make the wine called Diachyton, famous for its excellent bouquet, the grapes were dried in the sun for seven days on stands placed far above ground, taking care to keep them from the access of dew during the night. In this case a greater amount of sugar was produced, as always happens when fruit is gathered & caused to ripen in store houses. The wine must therefore have contained a greater quantity of alcohol, and the presence of the Husks may also have contributed to its flavour. The wine called by the Greeks (Sireen) of a remarkably sweet quality, was obtained by boiling the must of grapes until it was reduced to two thirds of its original bulk. It is asserted that the Greeks & the Romans were acquainted with about 80 varieties of wine. The celebrated (Falerno) must have been very rich in alcohol, since we are told that one of its principal characters was to undergo combustion when a light was applied. The Greeks & the Egyptians used to prepare a fermented liquor of barley and water to which the name of οινος κριθινος had been applied and later

that of "cervoisa" (Herodotus II, 77. Pliny XIV, 22)
The wines made from the palm tree were sweet aqueous liquors made to undergo the alcoholic fermentation and containing various quantities of acetic acid, tartaric acid, bitartrate of potash and other acid salts. —
"Hydromel" of which the name indicates the nature, was a fermented liquor much used in remote period, and even to this day in the North of Europe.
To prepare it, a certain quantity of honey was boiled in three times its weight of rain water; the mixture was then allowed to ferment in casks exposed to the sun.

Pliny observes that of all these artificial wines, none can be preserved more than one year, and several hardly 30 days.

The Ancients were acquainted with certain chemical methods used to prevent or correct the acidity of wine.

At present when wine has undergone the acetous fermentation, alkalis or alkaline earths are employed to neutralize the newly developed acid. The Carthaginians, the Greeks & the Romans sweetened their wines with calcined chalk or with the salts obtained from the burnt stalk of the vine or oak, and even with the lees of wine, dried and burnt (Pliny XIV 19 & 20)
Litharge was not used, as it destroyed the color of the wine and produced deleterious effects upon the health

Instead of syrup of dextrine, which is now sometimes made use of to improve beer, and even wine, they employed the juice of the grape evaporated to a syrupy consistence. This decoction was mixed with wines too acid or too deficient in sugar. (Pliny XIV 19)

Roman connoisseurs appear to have been very fond of wines having a slight taste of essence of turpentine. It is now known that turpentine taken internally, communicates to the urine a very agreeable violet perfume; perhaps that was one of the principal reasons for the ancients making use of that substance. Anything of the kind might have been expected from such zealous Epicureans as Horace who boasted he was one of: Epicuri e Grege porcus.—

The following was the method employed for preserving wine: — when the fermentation of the must was nearly at an end, some pine resin was thrown into it, by this process, a check was put to its ulterior fermentation. The resin acts in this instance in the same manner as hops, in the fermentation of must for beer, all essential oils preventing fermentation. Authors who like Cato & Columella have written on this subject in order to prevent the wines from undergoing a second fermentation prescribe that the casks should be coated with rosin. They therefore were evidently aware of the existence of two distinct kinds of fermentation; one, which was necessary to the production of wine, the other, which was to be avoided.

Wines which had become sour from this second fermen=tation, were called "Vappa". The same word was applied to persons of dissipated habits. In the present time, wine is preserved by previously burning sulphur in the casks in which it is to be kept; a process which appears to have been known in the time of Cato. The sulphurous acid thus produced, possesses in regard to the fermentation of wine the same properties as essential oils.

The lees of wine were not neglected by the ancients; they were dried & burnt in order to obtain the ashes which were used for the same purposes as the salts of vegetable acids (Pliny XIV, 20)

"Nulla in parte mundi cessat ebrietas" said the Romans after having conquered the world, ...

The use of wine increased proportionally with the power & splendour of Rome, but did not decrease with its fall. Pliny says that Mark Antony composed before the famous battle of Actium an apology for drunkenness the loss of which is hardly to be regretted. It was probably through a kind of mental aberration that the sensual friends of Lucullus took hemlock before a feast in order that the fear of death might make them drunk as much as possible, wine being considered an antidote for Hemlock.

Aristotle appears to have had the first idea of distillation 300 years B.C. He frequently speaks of the vapor-izations of water by heat, and its condensation by cold. That fact, so simple as it was, ought to have led to the discovery of Distillation.

"Sea water, says Aristotle may be rendered drinkable by Evaporation. Wine and every liquid may be submitted to the same process; - after they have been converted into moist vapour they again become liquid."

It is singular that after this remark, so acute a philosopher stopped short of the discovery of Alcohol which was in fact delayed for nearly nine centuries until the experiments of Alexander of Aphrodisias, six hundred years A.C.

The substance which was first obtained by distillation was oil of Turpentine prepared from an Exhudation from the fir & cedar trees. Pliny thus describes this process:— "A fire is lighted under a receiver full of resin; the vapour rises & condenses on wool placed before the orifice of this receiver. After the evaporation, the oil is expressed from the wool and is called "Pisenon or Pissoleon." (Pliny XV; 7)

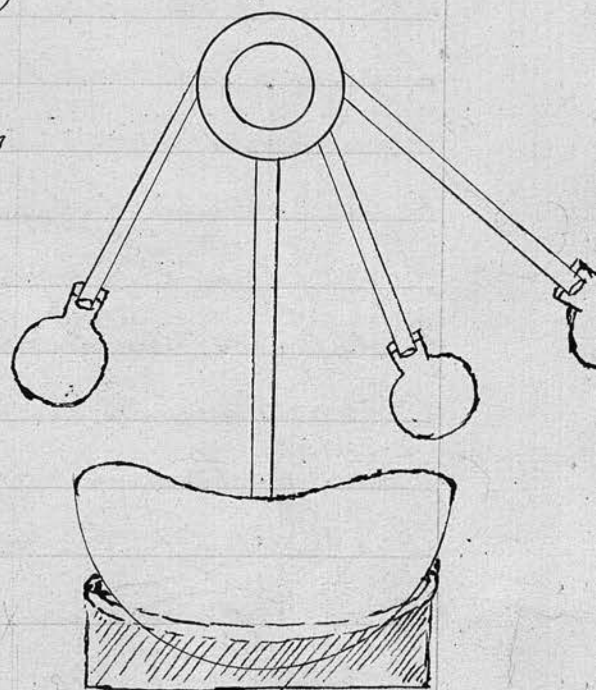
In the above operation, a pot was used as a retort, and a woollen stopper as a receiver, the residue was called pix or sometimes pitch or Colophon, from whence the name of Colophony.

This process, or the distillation mentioned by Pliny who is far from considering himself as its inventor (for its discovery) appears to have been as remote as 2000 years ago brings to mind the following lines of Alexander of Amphrodesius, "mentioned by Humboldt"

"Sea water, says Amphrodisius may be rendered drinkable
"by evaporation in jars placed over the fire, the condensed
"vapours being collected in receivers" Amphrodisius lived about 150 years after Pliny the naturalist.

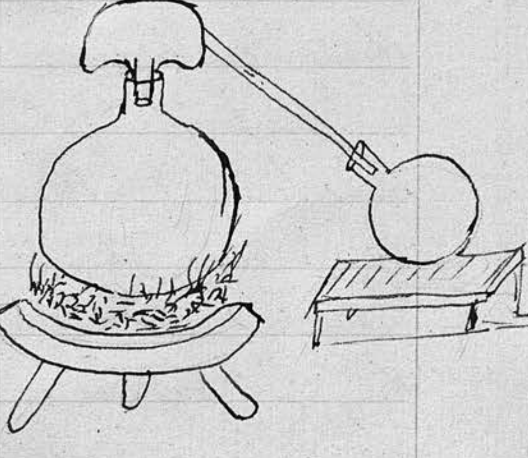
Zozimus, who lived at the end of the third ~~[illegible]~~ or beginning of the fourth century, ~~[illegible]~~ the chief or principal master of the sacred arts, was the first who constructed a suitable distilling apparatus, or as he terms it, a tribicus. He describes it as being made in the following way: — " Take three brass tubes of a considerable degree of thickness and of about 16 condees in length; ~~[illegible]~~ — placed in the inferior part of a glass jar, are to fit exactly into these tubes which open themselves into other smaller receivers. A large tube establishes a communica[tion] between the vessel under which the fire is lighted, and the great glass jar. Contrary to all expectation, this apparatus causes the spirit to rise. After having thus disposed the apparatus, the joints are carefully converted; care must be taken, that the great glass jar placed above the receiver with which it communicates should be thick enough to prevent its being broken by the heat, which causes the water to rise.

Synesius the commentator of Democritus who appears to have lived 50 years posterior to Zozimus, gives in his commentaries the description of another glass apparatus (of which fig 2 is a diagram) it is similar to those in use at the present time



The art of distilling was greatly perfected in the 16th Century.

Humboldt in his work entitled <u>Examen Critique de l'histoire de la geographie du nouveau continent</u> has described some very interesting facts in reference to the history of science. – Referring to the of the Asiatics he says: "it appears that they perceive no difference between alcoholic liquors obtained by distillation and liquors resulting from a continued vinous fermentation

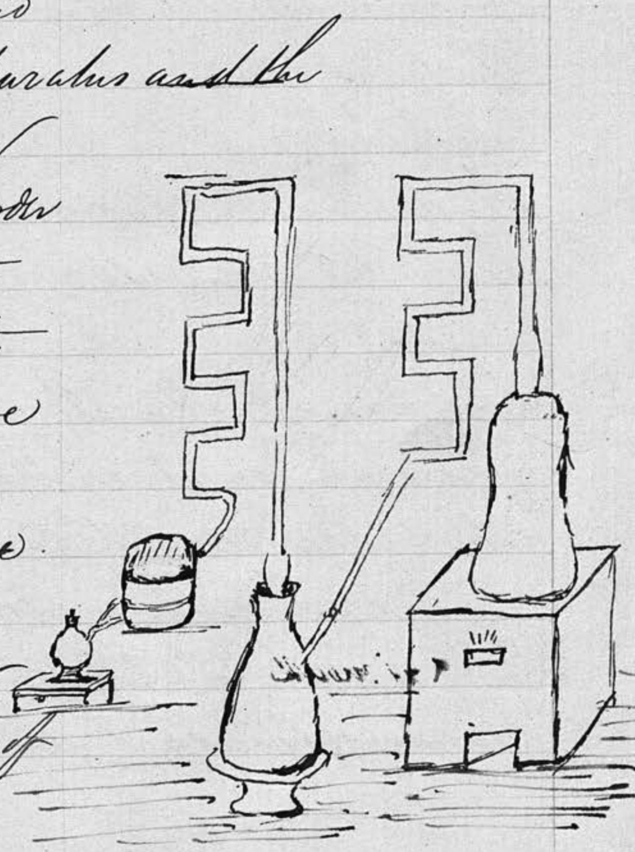


" Thus, the word Koumyss ought strictly to be applied to
" mares milk which has merely undergone fermentation
" although it is sometimes used to designate the substance
" obtained from its distillation. About Ghazi describes
the great feast given in 1251 by Mangou says he of the
Koumyss " clear as Brandy, from Grain twice distilled.
Returning from the Caspian Sea in October 1828 says
Humboldt, I witnessed the distillation of mares milk
in the Stepps of the Kalmouks between the Volga and
the Jayk. Amidst this group of nomade people,
the intoxicating liquor which has merely undergone the
vinous fermentation assumes after it has been beat
up the name of Kumiz or Koumyss. The Koumyss or
Tchighan after one distillation is called Araka.
The Araka again distilled, produces a still stronger
called arza. —
Some chemical experiments of Mr Vogel have recently
shewn that cows milk is capable of undergoing the
vinous fermentation. A great many Chemists however
deny this. Mm Persoz has shewn by some ingenious
experiments, optical as well as Chemical, how sulphuric,
citric or acetic acid causes sugar of milk to ferment
and thus give rise to an abundance of Alcohol.
The Kalmouks call sour milk from the cow Airak; the
brandy obtained by the 1st distillation of that milk

arki, by the 2nd Dang, by the third arza, 4th Khoztsa, the 5th Chingtsa the 6th Dingtsa. Such is their taste for strong liquors that the milk is sometimes made to undergo six successive distillations.

Rubens of Ravenna and Kunrath have left us special treatises on distillation. Rubens states that the celebrated Como de Medicis, the Dukes of Ferrara & other Austrian princes had studied and practiced the distillation of herbs, brandy, essences &c. —

Conrad Kunrath of Leipsic has left a very extensive work on the distillation of ~~wine~~, sea water, Urine, honey, wax, sugar, aromatic substances, resin & a great many other organic substances. For the purpose of distilling he employed a naked fire, water or sand or oil ~~bath~~. The tube of the apparatus and the and the receiver were carefully kept wet with cold water in order to condense the vapours; they were always made to circulate in long serpentine tubes before they reached the receiver.



Although the extraction of ~~wine~~ brandy from wine appears to have been known at a very remote period, a great number of years elapsed before the shameful habit of using it as an intoxicating beverage had become habitual. In the MSS No. 7478 of the XVI century of the Bibliothèque Royale we find a curious chapter which is as follows.

The following are the characters & properties of Brandy.
" Brandy is useful to allay any kind of pain resulting
" from cold, from inordinate or too great abundance
" of the animal fluids. It may be applied to eyes
" bathed in tears & consequently painful. It is also useful
" to all persons labouring under the inconvenience of
" bad smelling breath, as well as in all cases of dropsy
" resulting from cold. It is a specific for incurable
" diseases, for mortified wounds, for sores which may
" attack ladies hands, for bites of venomous serpents &c

It would be too long to enumerate all the diseases for which brandy was considered a sovereign remedy. The spirit distilled from wine could also lengthen life whence it was called aqua vitae. It was still sold in the XV century in the druggists shops, being considered as a medicament rather than a beverage.

Everybody desires a long life; we need not therefore be astonished that men, hearing of such marvellous properties attributed to this aqua vitae, should have been induced to make an inordinate use of it; and when these absurd stories had ceased obtaining credence, brandy had already become an article of food, a regular beverage. At the end of the 16th Century its use had extended to nearly all the countries of Europe especially among the lower classes.— In the Northern parts of Europe, such as the North of Germany, Sweden, Denmark, Russia and generally in countries where the vine did not grow, brandy was an expensive article, and the idea of producing it from grain which arose under these circumstances caused a complete revolution in Commerce. This practice however, far from being encouraged by Governments was to a certain extent checked ~~from~~ religious motives, as leading to a profanation of that matter which constitutes the daily bread. —

We now arrive at a very interesting period, when Carbonic acid was first discovered in the year 1577.

This important discovery is due to Van Helmont, as well as the discovery of several other elastic fluids to which he gave the name of Gases.— Van Helmont tells us, that:-

"Charcoal, and in general, substances which are not immediately converted into water necessarily evolve by combustion some esprit sylvestre (as he calls it) Sixty two pounds of Oak wood produces 1 lb of ashes the remainder has been used for the production of esprit sylvestre. To this unknown spirit which cannot be contained in jars or be converted into a visible body,

"I give a new name, viz Gas. There are bodies
"into the composition of which this Esprit enters, and
"others which are entirely composed of it; the Esprit
"is in this case as if fixed & solidified. By means
"of a ferment it may be made to emerge from this
"state, as occurs in the fermentation of wine, bread,
"hydromel &c.
The Esprit sylvestre of Van Helmont is what we call
Carbonic Acid. The same author adds that the gas produced
by the combustion of charcoal is the same as that evolved
during fermentation. On another occasion, he
defines fermentation as "the mother of transmutation
" dividing bodies into extremely small atoms." – He adds
that grapes only ferment when in contact with the
atmosphere, and that the gas which is produced is the
same as that which causes wine to effervesce.
He expresses himself as follows:–
" A bunch of fresh grapes may be preserved & dried, but
" when once the epidermis is torn, the grape soon undergo
" fermentation, which is the first stage of its metamorphosis
" Thus, must of wine, honey, the juice of apples, of berries
" & even of flowers & wounded branches, undergo, under the
" action of a ferment, the species of effervesance arising
" from the evolution of gas. Dried grapes take more
" time to evolve this gas, as they are deficient in ferment.

"It is this gas which, contained to a great extent in Casks, renders wine sparkling."

The author next endeavours to shew that this gas differs entirely from Alcohol

"Led astray by ignorant writers, (he observes) I believed the gas evolved by grapes, to be nothing else than Alcohol."

Van Helmont also considers the gases which escape from the intestines to be Gas Sylvestre

"Any wind, says he, which is produced inside our body by the digestion of food or by excrements, is Gas Sylvestre"

He adds

"The Gases from the stomach extinguished a lighted taper, but those produced in the large intestines & make their exit by the anus, burn in a lighted taper with ~~and~~ a blue (iresce) flame"

The observations of modern Physiologists tend to shew that the gases from the stomach & the small intestines are generally, Carbonic Acid and common air. ~~[illegible]~~

"The Gases which are produced, adds Van Helmont, in the small intestines are never inflammable, often devoid of smell & of acid quality, varying in short according to matter, shape, locality & fermenting properties."

We may here mention that Van Helmont was one of the first who admitted the existence of a Gastric juice in the stomach.—

" That acid, says he, is as necessary to digestion as the constant
" heat of the body. In the duodenum, the acid of the stomach
" meets the bile which acts as an alkali; they combine together
" somewhat in the same way as vinegar and minium
" and by this combination, lose their former properties.
" The acid of the stomach, where it accumulates in too great
" abundance may produce a great number of diseases
" such as Rheumatism, Gout, Palpitation, Gangrene
~~#~~ We now come to one of the most distinguished
philosophers of the XVII th. Century (Robert Boyle)
born 25th. January 1626.
" Which of his numerous works, (says Boerhave one of his
" great admirers) is most deserving of praise ?
" To him we owe the secrets of fire, air water, animals,
" vegetables, fossils, so that from his researches may
" be deduced an entire system of physical natural
" science.
Boyle made a series of Experiments to prove that alcohol
does not exist ready made in the juice of grapes, but
that it is produced by the fermentation of the must,
& that fermentation itself cannot take place in vacuo
The author concludes from his numerous and
remarkable experiments, that there is some vital
substance in the air which plays an important part
in the principal chemical phenomena viz combustion,

formentation & respiration, that substance may be solar, sidereal or of any other nature.

" It is (he adds) singular that there should be something
" in the atmosphere which should especially contribute
" to the production of flame, so that when once the substance
" is consumed, the flame should immediately disappear

Boyle was the first to show that the distillation of wood gives rise to the production of vinegar and alcohol, which he called anonymous spirit or Diaphorous spirit.—

He separated these two liquids obtained together in a receiver by submitting them to a fresh distillation, the temperature being carefully regulated, so that the inflammable spirit only, passed over.

The distilled liquid being subsequently mixed with lime the acid seized upon it and the rectified spirit was obtained pure by a final distillation

In order to concentrate the alcohol, ~~the author~~ distilled it with Carbonate of Potash or with Caustic lime.—

" There is, ~~he~~ adds, by this process, a double Economy
" both of time & of Expense, for the residue, properly dried
" may be used more than once for this process.

In the 17th Century may be mentioned another Chemist "Kunckel"; he is the first who appears to have established a distinction between fermentation and putrefaction. He observes:—

" Fermentation are sisters; they are closely connected
" with each other. In the animal Kingdom, fermen
" may be distinguished by its fetid smell; as soon
" as it ceases, putrefaction is also at an end. This tak
" place as soon as water, and light have again seized
" upon the Elements which belonged to them, so that
" nothing remains but a little dust & Earth.
" A gentle heat & moisture accelerate both fermentatio
and putrefaction."

Kunckel prepared Alcohol from raspberries & other saccharine fruits, made to undergo fermentation; He appears to have been aware that the acid found in fermented liquors was produced at the Expense of the alcohol. He says:—

" Mash some Mulberries & expose them to a very slight hea
" they will begin to ferment.— As soon as the heap
" of Mulberries begins to subside & that they give off a
" vinous & slightly sour smell, let them be distilled
" good spirit of wine will be obtained, but not so
" much as if the action had been increased by the
" addition of a little leaven or yeast of beer; for withou
" it the fermentation is slower, and a great deal of acid
" is obtained at the Expense of the Alcohol. Some theoreti
" chemists contend that spirit of wine is a kind of
" oil, but none of the characters of oil belong to this substan

for it does not float on water or dissolve sulphur; it does not produce soap in combining with alkalis."

Kunkel observes truly, that acids, bitter plants, essential-oils and coal are as many obstacles which immediately put an end to fermentation.

Acids prevent fermentation because they themselves are the result of that fermentation. If during the fermentation of sugar a few drops of sulphuric acid are added, the fermentation will be seen to stop immediately; cold acts in the same way."

The same author attributes a great number of the diseases of the stomach to a kind of fermentation, and accordingly makes use of substances which check fermentation to cure them.

Pains in the stomach (he observes) arise evidently from the fermentation of impurities, since they are easily cured by using acids or bitter plants, which check fermentation. Sugar is injurious to the stomach & favours its diseases because it promotes fermentation.

The ferment which, as is well known is a nitrogenized principle, was already considered by Kunckel as capable of evolving ammonia by the application of heat.

Kunckel has left us some very interesting details on the preparation & distillation of essential oils and alcohol, his process is very ingenious. He says: —

" I dissolve a little sugar in hot water & put the solution
" in a retort, after having added a few tea spoons-
" full of yeast of beer. When I consider the
" fermentation to be in full action I add the flowers
" whose essence I wish to obtain, I next close the retort
" and connect a tube & receiver, the mixture is then distilled
" at a low heat. In this manner an excellent spirit
" is obtained containing any essences of flowers or
" herbs. The first portions which pass over contain
" the most essence and the last portions the least.

Is it not possible that the alcohol at the instant of its development, by the fermentation of sugar, being in the nascent state should be readier than in any other condition to seize upon the essential oils of plants, and carry them into the receiver.)

<u>Sala</u> In the year 1602 <u>Angelus Sala</u> began practicing medicine in Dresden; his works were published after his death in a single volume; they contain interesting details on sugar, on tartar, on the distillation of essences, brandy &c. Sala states that sugar may be clarified & refined by means of white of egg & chalk. He refutes a very common error, that calcined chalk communicates to sugar, unwholsome properties. He ascertained that an aqueous solution of sugar with a little yeast of beer produces after a certain time a considerable quantity of spirit (wine

He does not ~~of~~ allude to the aeriform substance which we call Carbonic Acid; He considers vinegar as a product of decomposition of Spirit of wine.
It is remarkable how carefully Sala regulated the temperature & maintained it constant by means of sand baths, ashes, oils &c when distilling essences & other volatile products.—
He defines fermentation as being "A spontaneous motion of the elementary particles which have a tendency to unite in a different way so as to produce a new compound. It is difficult to give this phenomenon a clearer definition. According to the Alchemists all substances are susceptible of undergoing fermentation.
Sala opposes this view, and limits that process to organic bodies. The beer which was at that time made in Germany contained much more alcohol than that of the present time. The celebrated beer of Bernburg for instance contained about 15 % of alcohol. He ~~author~~ states that the Spanish wines contained a similar proportion.— To the existence of this fact, the beer of Bernburg owes its intoxicating properties.
The cider of Normandy, or the fermented juice of pears or apples is considered by Sala to be very rich in Alcohol. We find in his hydrology a chapter containing ample details on the preparation of brandy from grains:— He says:—

"All the inhabitants of the North are acquainted wi
"the method of making brandy from grain. For th
"purpose, it is first roughly pounded, and then cast into a
"vat; tepid water is then thrown upon it and the half
"liquid paste is stirred up with spatulas. Yeast of
"beer is next added and the whole allowed to ferme
"It is necessary to be to a certain extent, in the habit
"of practicing this process, to know when the fermentatio
"is quite over & when the time is come to submit the
"matter to distillation and extract its alcohol. —

This process for obtaining brandy from grain was kno
before the 30 years war (the year 1618) It was much
practiced in the district of Magdebourg & especially in
the town of Vernigerod then belonging to the count
of Stallburg. —

Boyles researches were continued by Ch Wren in
the year 1664, he was the first who had the idea of
collecting the elastic fluid or Carbonic Acid, which
is evolved during fermentation. For that purpos
he made use of a bladder connected with the orifice of a
pipe which opened into the receiver containing the
fermentary mixture. He observed that this fluid,
similar, he says, to the atmosphere, was absorbable by
water.

In the same year Hook made use of a retort furnish

with two apertures connected ~~with~~ by means of two tubes.
He introduced into it some oyster shells and aqua fortis & collected in a bladder, the elastic fluid which was evolved, but he made no enquiry as to its composition.
Jean Bernouilly, in a very remarkable dissertation upon effervescence & fermentation, announced some fresh discoveries relating to the nature of elastic fluids. Treating of fermentation, he observes that bread owes its porosity to gases which cause ~~the bread~~ it to rise and assume a spongy appearance and that the reverse takes place with unfermented bread, which is heavy & compact.
Of all the Chemists of the 18th Century, the one who undoubtedly contributed the most to the advancement of Chemical science was the celebrated Joseph Black, born in 1728. He succeeded Cullen, as Professor at Glasgow in 1756 and in 1766 was called to the Chair at the University of Edinburgh. He died in 1799 after a long & useful life, respected not only by his numerous personal friends but also by the whole scientific world. His works were collected and published by his favourite pupil Robison
Among his most important discoveries may be mentioned, that of Carbonic Acid which he called "fixed air" Bergmann changed this name

into that of aerien acid and it was finally called Carbonic Acid Gas.
In the year 1756, Black discovered that the air produced by fermentation was fixed air. We have already seen that Van Helmont was acquainted with that same gas under the term "Gas sylvestre".
Several Eminent Chemists such as McBride, Cavend[ish] and Jacquin followed up the discoveries of Black. Mc Bride generalized Blacks ideas upon fixed air.
"Of the three kingdoms (says he) the animal kingdom
"contains the least fixed air, & the vegetable kingdom
"the most. Fermentation and putrefaction
"are checked when a stop is put to the evolution of
"fixed air, and in causing this air to come in
"contact with putrefied substances they may be
"restored to their primitive condition.
"It is on this account that he advises the use of beverag[es]
"containing fixed air, such as must of beer, for the
"cure of scurvy, which he defines as a putrid disea[se]
"arising from a deficiency of the principle which conn[ects]
"and cements bodies. McBride tells us that he has rendered putrefied meat wholesome by restoring it the fixed air it had lost, either by submitting it to the direct action of fixed air, or of the air which is evolved from a fermenting substance, or of the gas

produced by the action of an acid upon an alkali. (Carbonate)
According to this author, astringents act as powerful antiseptics in contracting the pores of the body, thus preventing the escape of its fixed air and consequently the diminution of parts which would lead to their putrefaction. In his experiments on Chalk McBride endeavours to shew that the aggregation of the particles of this substance is merely owing to the quantity of fixed air which it contains, which if it escapes may be restored by causing a fermenting substance, or merely the gas evolved from it in its free state, to act upon the chalk. It hastens putrefaction & decomposes animal matters by taking from them the fixed air which they contain. Lastly the author endeavours to shew experimentally that the volatile alkali developed by the putrefaction of animal matters is sometimes combined with fixed air & at other times is caustic, that is, free from this air. He pretends also to have discovered that putrefied blood, as well as the spirit which can be obtained from it, effervesces with acid & putrefied bile. The liquor obtained from putrid flesh, is not liable to the same action.
In the year 1745, experiments were made by Marggraff relating to the extraction of real sugar from various plants growing in our climates. Marggraff concludes that

among the indigenous plants which contain sugar, the beet root & carrot contain the greatest amount, that this sugar is perfectly analogous to cane sugar, that it exists in that state in the plants; & that the most easy way of extracting it is by drying the roots & boiling them in spirit of wine, which dissolves out the sugar & allows it to crystallize on cooling. He adds that the dry roots not only possess a sweet taste, but show under the microscope, particles of a white & crystalline appearance similar to that of sugar. It may be worth while to observe that this is the 1st time in the History of Science that we see the microscope made use of in Experimental researches.

Boerhave, who flourished about the middle of the 18 century appears to have been the first who detected, three species of fermentation viz the Vinous, the Acetous & the Putrefactive, each being distinguished by the product it afforded as well as by the nature of the phenomena which it presented. He supposed that these three kinds of fermentation succeeded each other in an invariable order, the vinous always preceding the acetous, and the putrefactive being the last.

Although several chemists before the time of Fourcroy ventured to modify to a certain extent the above theory ~~to a certain extent~~, it was still admitted by the majority of Phi

Rouelle in his lectures also adopted this division of the subject.
As we have already observed, each of these fermentations were characterized by their respective products; the vinous or spirituous producing spirit of wine or ardent spirit as it was called; the 2nd. giving rise to vinegar (the acetous fermentation) the 3rd. the putrid or alkaline fermentation, so called because volatile alkali or ammonia was considered as being invariably produced by it.

A few chemists however, & among them Bucquet in the latter period of his life, as appears from his last lectures between 1776 & 1779 believed that this division into three classes was not sufficient to express the various alterations, or fermentations which vegetables could undergo. They considered the action of yeast on bread as giving rise to a distinct species of fermentation, which they called panary (fermentation panaire) But, says Fourcroy in his great work published in the beginning of the present Century; — An acid is produced by the panary fermentation; it is consequently to be considered, as belonging to the second ~~class~~ or acetous fermentation of Boerhaave."
Some of the above chemists also distinguished a peculiar species of fermentation by which colouring particles

were developed, such as takes place with the indigofera the pastel.

Fourcroy who studied very minutely the subject of fermentation, was of opinion that two new species were decidedly to be added to those of Boerhave. He thus admits of five different ~~species~~ fermentations.

1st Saccharine.
2nd Vinous.
3rd Acid.
4th Colouring.
5th Putrid.

He gives the following axioms or principles, which tend to shew to what extent chemists were already familiar with the subject of fermentation.

1st Principle: It is necessary to distinguish fermentation from the following phenomena:—
1st Formation of Soil
2nd Formation of Bitumen
3rd Fossillization.

2nd Principle. A certain degree of heat is necessary for fermentation; it can hardly take place under 15° R.

3rd Principle. Water is necessary for fermentation; it acts in dispositing the particles of the substance.

Since the time of Stahl, says Fourcroy "Chemists have adopted the theory called the theory of ferments, which has been applied to far too great an extent in medicine. Physicians have been led to believe that a phenomenon resembling fermentation took place in a great many diseases, & that all those resulting from a poison (virus) & especially from inoculation or the introduction of any foreign matter into the circulation arose from an intestinal motion produced by a ferment.

It is now known, that when foreign ~~particles~~ bodies are introduced between the particles of different vegetable substances they excite the particular fermenting process to which these substances are naturally predisposed. It is not necessary that these bodies should have already ~~have~~ undergone fermentation, although had this been the case the action would have been more rapid. All foreign substances capable of disjoining the particles of bodies & causing their mutual attraction to diminish enjoy the same property. Thus, Carbonic Acid, from its easily assuming the gaseous condition, or occupying a greater space, pushes aside the particles of the bodies between which it is interposed, and is particularly endowed with the property of causing those bodies to ferment or of developing more rapidly the intestinal motion, which is apt to cause a modification of their nature.

66 This discovery we owe to an English Chemist "Mr Henry"

We must here close the history of fermentation; Fourcroy had already such extensive & true notions on this subject that many of his views will be [illegible] hereafter, ~~but~~ his theories will also be discussed in their place.

Definition of Fermentation.

The phenomenon called Fermentation is a modification excited in the chemical composition of an organic substance by the presence of a second body (or ferment which takes no chemical part whatever in that transformation. —

Chemists are in the habit of considering a number of different fermentations which have generally been named according to the products they generated. The following are those which are now commonly admitted and which we shall proceed to study in succession. —

The Saccharine Fermentation. —
— Alcoholic —
— Lactic —
— Viscous —
— Butyric —
— Acetous —
— Benzoic —
— Pectic —

Putrefaction has been considered by some Authors as constituting a peculiar fermentation. A few words will be added upon that subject, tending to shew that putrefaction though at the first sight somewhat similar to fermentation is nevertheless quite distinct from that phenomenon. —

Saccharine Fermentation

Saccharine fermentation is the phenomenon which takes place, when starch under certain circumstances is converted into sugar

Our intention in this essay is to study successively the nature of the above phenomenon; the causes to which it is owing; the modes by which it may be checked or increased.

During the germination of Grains a saccharine substance is developed within them; this occurs for instance in barley when it is converted into malt; - - - - - - - -

If moist barley be heaped up in a warm room, an intestinal heat may soon be perceived to develope itself in the grains as soon as they evince a tendency to ~~germinate~~ germinate;

If now it be scattered over the floor, its germination will readily take place & a sweet infusion can be obtained from it. A saccharine substance due to the specific fermentation we are about to describe may thus be developed in the barley which did not exist there previously.

This phenomenon has recently occupied the attention of chemists the experiments of De Saussure, Berzelius, Bouchardat, Huber & others tend to explain more or less satisfactorily its nature.

De Saussure after a careful analysis of corn, before

& after it had undergone germination, arrived at the following conclusion.

100 Parts of Corn gave

	Before germination	After germination
Starch	72.72	65.80
Gluten	11.75	7.64
Glutinic dextrine	3.46	7.91
Glutinic Sugar	2.44	5.07
Albumen	1.43	2.67
Bran	5.50	5.60

Therefore after germination 2.6 parts of sugar & 4.5 p. Dextrine had been produced from the modification of 6.9 of starch & 2.9 of gluten, adding the albumen, which is one of its most abundant constituents. "The aqueous
" solution of that sugar, says De Saussure, reddens litmus
" it is precipitated as well as the solution of dextrine by an
" infusion of Galls & subacetate of Lead."

By mixing starch & gluten at a temperature of 40° to 6 dextrine & sugar are also produced upon which those reagents have a similar action. Grains contain a certain amount of Gluten & a great quantity of starch. The sugar & dextrine produced during the germination thus probably depends on a similar action of its gluten upon the starch which it contained.

We shall endeavour hereafter to determine whether this action or fermenting process be connected with germination.

The Characters of Starch sugar have been accurately pointed out by Knapp:—

" Starch sugar he observes, assumes the state of spherical
" crystals. It is not so hard, nor so sweet nor so soluble
" in water as common sugar. When digested with
" an alkaline Carbonate or with Chloride of Tin, a precipitate
" of mucilage is thrown down (Henry vol 2nd P 244)"

Conditions exciting or favouring Saccharine Fermentation

1st The presence of Atmospheric Air.

This condition though not strictly indispensible is nevertheless very important for the production of saccharine fermentation.

Mr Cruikshanks believes he has sufficiently proved ~~that~~ the presence of air is necessary to the production of sugar from grain, because he found that ~~[illegible]~~ change did not take place when barley was moistened & kept in vacuo; but de Saussure has shown that the presence of air is not indispensible, though it considerably accelerates the process (Observations sur la decomposition de l'amidon par l'action de l'air et de l'eau - Ann de Chemie et de physique vol XI). Thus he obtained at a temperature of 18° to 24° but a small amount of sugar & of gum from Corn kept for four days under water

& from which air was completely excluded, but by keeping the grain under water for 6 months, 100 lbs of dry grain yielded

Starch	61.81
Gluten	0.81
Gluten Dextrine	1.93
Glutinic Sugar	10.79
Albumen	8.14
Bran	4.07
Carbonic Acid	3.38

together with various quantities of acetic & lactic acid, & alcohol.

Since the atmosphere plays so important a part in the phenomenon of fermentation, it is natural to enquire to which of its elements it is principally owing. Huber has settled this question by examining the action of Nitrogen & of Oxygen upon different seeds disposed to germinate. Having placed grains of lettuce on a moist flannel, he introduced them into a receiver full of Nitrogen Gas; they did not germinate till after the lapse of a considerable space of time, altho germination began after 22 days in a similar receiver full of atmospheric air. In this experiment though the volume of the Nitrogen had not been sensibly altered

a slight trace of Carbonic acid was found, mixed with it at the end of the Experiment.
Huber next placed grains of lettuce in oxygen gas where they germinated 5 or 6 hours sooner than others left in the open air. He observed that the oxygen which excited the first developement of the germs, sometimes produced an unfavourable action upon the young plants, the radicals becoming brown, and appearing to undergo an incipient putrefaction. The oxygen gas diminished in volume, and was partly converted into Carbonic Acid, which produced a precipitate on the addition of lime water. This was due to a combination of the grains with part of the oxygen.
Huber admits that it is impossible to suppose that this Carbonic acid is evolved from the grains themselves, because, first in that case, there would have been an increase instead of a diminution of volume of the gas, and secondly, if the receiver had contained a mixture of oxygen & of Carbonic acid, the latter being exclusively derived from the grains, after agitating lime water in the receiver there would remain the original bulk of oxygen, which was far from being the case, since the volume of the gas had considerably diminished. It has moreover been

mathematically proved by De Saussure, that the amount of Carbonic Acid ~~formed~~ found in the receivers where grain had germinated, contained exactly the amount of oxygen gas that had disappeared.

In a third experiment Huber composed an artificial atmosphere by combining oxygen and nitrogen in the same proportions as in the air, the germination of seeds went on though not quite so rapidly as in the common air, owing as he afterward discovered to the small amount of Carbonic Acid in the atmosphere. (Huber, Memoirs sur la germination)

We therefore arrive at the conclusion that the atmosphere yields oxygen for the saccharine fermentation or the germination of seeds, & that its carbonic acid has the power of slightly accelerating that process. —

— Saccharine fermentation is always accompanied by an increase of temperature.

Thomson observed that the temperature of Barley heaped up for obtaining malt rose to 38° Cent. The radicles had grown in a single night 13 millim.

— De Saussure has made a series of experiments on this subject so full of interest that we may perhaps be allowed to enter into a few considerations in reference to them. He caused 140 grammes of peas to swell up under water for 24 hours, so as

to induce them to germinate. After he had drained the water, they were enclosed in a cylindrical capsule of about 8 centimet diameter & height.
These peas were kept moist by a wet sponge which also maintained a free access of air.
He placed in the middle of the capsule the bulb of a thermometer whose degrees were each divided into 12 millimetres. Twenty four hours after this was arranged, and before the germination had commenced, the temperature of the peas had risen 0.6° R higher than the external air.
After the following 24 hours, the germination had commenced and the excess of temperature of the peas rose to 1°, which increased in the five following days to an average of 1°44. After another lapse of nine days, the plumules had appeared and their average excess of temperature was 0°87°. A month after the beginning of the experiment, the excess of temperature was reduced to 0°6° which remained appreciable for a long time, but decreased with the gradual developement of the seeds.

De Saussure has proved by another series of experiments that a wound on the surface of seeds placed in circumstances favourable to germination augments the destruction of oxygen gas, during their developement without however increasing or delaying that action in the beginning provided the section does not affect the germ. He experimented on peas in two different ways: 1st. In cutting off ~~the~~ a small segment which appeared to destroy the germ 2nd by cutting a segment equal to the preceding one but leaving the germ untouched. The remaining parts, nearly of the same weight were placed in circumstances favourable to germination along with grains quite entire. The first set of grains took up more oxygen than those which had remained entire, the wounded peas with the entire ~~grains~~ consumed more oxygen than those which had been deprived of this appendage. In regard to the temperature acquired by the peas in this experiment, de Saussure found it increased in proportion to the amount of oxygen consumed; the excess of temperature of the entire peas over that of the atmosphere was about 1/4° R less than that of the wounded peas; and ~~[illegible]~~ of these last, those with the germs produced more heat, with equal weights than those in which that organ appeared to be wanting). None, however, putrefied during the 10 first days of the experiment on the contrary they had assumed a tendency to grow & develope themselves.

The great difference between the results obtained by ~~De~~ Saussure & the degree of heat witnessed by Thom~~ps~~son in the germination of barley is owing to the much greater quantity of grains used, and the consequently lower diminution of their temperature.

~~De~~ Saussure having performed similar Experiments with barley & corn, the elevation of temperature was ~~equal~~ found to be nearly Equal to that which was produced in the case of the peas; indeed the results obtained were almost analogous.

The temperature of the atmosphere exercises a decided influence on the germination of grain.

Thus the difference between the temperature of germinating corn and ~~that~~ of the external air was found to be 1.4 R when the atmosphere was at 15° R, but under circumstances, the same in other respects, that difference was diminished ¼° when the external temperature was at 11° R.

In order to discover whether moist grains were capable of producing heat when isolated from the air, de Saussure took 140 grammes of dry peas, which were then properly moistened & put into a bottle, so as to fill it entirely. The air remaining in the interstices between the peas having been replaced by water, the bottle was then carefully stopped with a perforated cork, thro' which passed a thermometer; a tube opening at one end in the bottle & at the other, under a receiver full of mercury, gave exit to the gases which might escape. The evolution of gas was very abundant but no perceptible heat was generated.

He repeated the experiment with an amount of peas 19 times greater. In this case the thermometer rose about ⅓° higher than the external air, which was then between 16° & 18°. This excess of temperature lasted for 12 days during the whole of which time the gas was escaping abundantly, but it decreased as the evolution of gas diminished. After a month it was reduced to 1/9th. — From these experiments we are justified in concluding:—

1st. That the excess of temperature of 0.6° in the case of the peas was necessary in order to excite their saccharine fermentation & that this temperature is produced by a primary combustion or combination of the oxygen of the atmosphere with the carbon of the grain, which combination readily takes place under these circumstances.

2nd That after a certain time, the temperature rises to 1°,44 owing to the heat produced both by fermentation and germination.

3rd That the cuticle which covers the peas prevents more or less the access of external air, and therefore impedes their saccharine fermentation.

4th That in the case of the wounded peas, the atmosphere acting directly on the starch appears rather to accelerate its conversion into sugar than to develope the germ.—

5th That saccharine fermentation is to a certain extent independent of germination (Phil Trans. 1819)

The Saccharine Fermentation requires the presence of a Ferment.—

Starch, in order to undergo the saccharine fermentation requires to be brought in contact with an azotized principle;—this principle in the fermentation of grains, is gluten, which is supposed to act upon the starch contained in the grain & to convert it into sugar during their germination. But gluten contains other substances besides nitrogenized compounds.

Berzelius made a series of experiments in order to discover their nature, and if any of them could be considered exclusively as ferments. He found that vegetable gluten might be decomposed into the following substances:—

1st Vegetable Albumen, insoluble in water & called by Taddey Zimome; this substance moistened with water has none of the physical or external properties of gluten, although according to the experiments of De Saussure, it constitutes in the dry state the 3/4 or 22/100 of that substance

2nd A gelatinous substance for which Berzelius has reserved the name of Gluten. It is insoluble in

hot & cold alcohol, nearly insoluble in water.
De Saussure calls it Glutine to prevent any confusion with the general term Gluten, of which glutine only constitutes the 11/50th part
3rd A Mucilaginous substance, as yet but imperfectly known, which De Saussure calls "Mucine"; it is more soluble in water than Glutine, & its solution in boiling alcohol becomes turbid on cooling. When dry it is granulated, transparent, and adheres to glass Its combustion presents the usual characters of animal substances. Impure & dry mucine such as de Saussure has used constitutes only the 4/100th part of dry gluten. He obtained it by boiling moist gluten in alcohol and afterwards mixing it with its volume of water and reducing it by evaporation in the waterbath to the 16th of its volume, more water being added & the whole being allowed to cool, the insoluble substance subsided & was separated by decanting the supernatant liquid. This latter evaporated to dryness yielded mucine. Its characters are the following It is only partly soluble in water, & its solution becomes turbid on cooling; 100 parts of water at the temperature of the atmosphere only dissolve 4 parts of Mucine. The solution does not affect vegetable colours. Water containing 1/50th of its weight of mucine in solution becomes very turbid by the addition of an infusion of galls, or of sulphate of Iron. It also becomes turbid

when acted upon by alcohol, by alkaline Carbonates & by Carbonate of Ammonia, by lime water, by baryta water, by subacetate of Lead, ~~by~~ Choride of Mercury and Ferrocyanide of Potassium.
The portion of mucine insoluble in water which constitutes about 3/4 of its weight is soluble in Acetic Acid, leaving a very sparingly soluble residue, which after numerous washings with alcohol & water, still ~~that~~ retains an amount of acid sufficient to redden litmus.
This residue, ~~is~~ completely insoluble in vinegar, produces with a weak solution of Hydrate of Potash a brown liquid; ~~on~~ ~~which~~ reagents had the same effect on it as on the albumen of Gluten, it was dissolved by that ~~alkali~~ potash.—
Mucine is insoluble in Ether; Its aqueous solution rapidly putrefies with an alkaline reaction, but in the dry state it is not altered by the action of the Atmosphere.
Berzelius: (vol VI Page 2) mentions among the different Elements of indigo a peculiar substance whose properties are similar to those of Gluten; he calls it gluten of indigo
It is obtained by digesting powdered indigo with a diluted acid; the residue is then boiled several times with water. If SO^3 has been used, in order to obtain it quite pure, the acid is to be separated with marble, the solution filtered & evaporated to dryness. The residue is then treated with Alcohol which dissolves the gluten and

leaves it after evaporation as a yellow or yellowish brown powder

This gluten is very soluble in water; heated on a platinum spatula, it fumes & leaves a white residue. Dissolved ~~[illegible]~~ in water, it is precipitated by the same reagents as gluten viz Tannin, Chloride of Mercury, Ferrocyanide of ~~Merc~~ Potassium &c; the latter substance only causes a precipitate when the solution is acid.

The gluten of indigo combines easily with both acids & alkalis; it differs however from gluten by its solubility in water, & by its not being of a glutinous or sticky nature. It is not coagulable by heat, nor is it insoluble in alcohol thus differing from albumen. Acids do not take up the whole of the gluten contained in Indigo; a part of it remains behind & can only be separated by means of Caustic Potash. Berzelius does not mention whether this Gluten is capable of converting starch into sugar, which however appears quite probable; the experiment we believe has yet to be performed.

In order to discover whether in the conversion of starch into sugar, one of the three elements above mentioned (constituting gluten) possess exclusively the properties of a ferment, de Saussure placed each of these substances in a water bath at a temperature of between 40 & 60 R with twice their weight of starch & the quantity of water

required to convert the whole into a paste.
He obtained the following results: —
100 Parts of Starch in the mixture containing the Albumen
produced 2 parts of dextrine & about 1/400th part of sugar
100 Parts of Starch in the mixture containing the Glutine
produced 6 parts dextrine & 1 3/4 parts of sugar.
100 Parts of Starch in the mixture containing the Mucine
produced 15 parts of dextrine & 22 parts of sugar
When the experiment was made with impure gluten
100 parts of starch produced 16 1/2 parts Dextrine & 14 1/2
parts Sugar.
Notwithstanding the difficulty of effecting a complete separation of the elements constituting gluten; we may conclude from the preceding experiments that mucine is particularly endowed with the property of converting starch into sugar & that the other elements also possess that property, but in an infinitely less degree.
M. Kirchoff has shewn that this saccharifying property of gluten contained in barley is capable of acting upon a greater quantity of starch than is contained in the grains that produce it. If for instance a mixture be made of one part of roughly pounded malt and two parts of starch with four parts of water to which four parts of boiling water are added, a strongly saccharine liquid is obtained, but we cannot as yet state any numerical results.

In order to ascertain whether starch would be converted into Sugar without the help of a nitrogenized compound de Saussure (Phil Trans 1819) prepared a paste composed of starch & 12 times its weight of water, and left it freely exposed to the atmosphere for two years. At the end of this time, the paste had become a grey liquid covered with mould, free from smell & having no action upon vegetable colours. The starch had lost nearly 1/4 of its weight & the remainder had been converted into the following substances.

1st Sugar amounting to half the starch

2nd Gum, or rather a substance resembling it & similar to that obtained by roasting starch.

3rd Amyline

4th Starchy Lignine

5th Lignine, mixed with Charcoal

Thus sugar was also obtained in this instance, though no Gluten had been added to the mixture; but it may be observed that the Atmosphere always containing some nitrogenized compounds derived from the decomposition of animal matter, some of this substance might have been absorbed by the mixture so as to act upon it as a ferment.

Another mode of converting starch into sugar was discovered by Kirchoff of St Petersburg; he obtained the result by boiling dilute Sulphuric Acid with Starch and water during several hours.

Mr Tuthill of London digested 1½lb of potato starch in a mixture of 6 pints of water (distilled) and ¼lb of Sulphuric Acid; he boiled the whole in an earthen vessel, stirring it frequently & maintaining a constant degree of fluidity by adding fresh water.

After the lapse of 24 hours a sweetness was perceptible in the liquid which increased till the end of the experiment.

Twenty four hours after, 1 ounce of finely powdered Charcoal was added & the boiling kept up for two hours longer. The Acid was then carefully saturated with recently burnt lime & the boiling continued for half an hour longer. The liquor was next passed thro' Calico and the substance remaining behind was washed repeatedly with warm water. When dry, the mass weighed 7/8^th^ Ounce & consisted of Charcoal & sulphate of lime. The clear liquid was evaporated to the consistence of syrup & set aside, and in the course of eight days converted into a crystalline mass resembling common brown sugar with a mixture of treacle.

The saccharine matter which Dr Tuthill judged to be intermediate between cane sugar & grape sugar weighed 1¼ lbs, by fermenting ~~lb~~ 1. of this substance in the usual manner & distilling and rectifying the product XIV Drachms by measure of proof spirit were obtained.-

In regard to this curious action of Sulphuric Acid upon Starch, it has been demonstrated by de la Rive of Geneva that the process goes on without the evolution of any gas, and that the alteration of the Starch continues to take place even in close vessels, without the contact of air. He also observed that part of the Sulphuric acid is decomposed or united with the Starch (Henry's Chemistry vol 2 Page 244) These results were afterwards confirmed by the Experiments of de Saussure (Thomson's annals vol pp 424), he also shewed that the sugar which is obtained, exceeds by about 1/10th the original weight of the Starch. He concludes from these Experiments that the conversion of Starch into sugar is nothing else than the Combination of Starch with water ~~in a solid state~~, a conclusion which is strengthened as Dr Henry observes by the result of the analysis of those two substances viz

	In Starch were found.		In Starch sugar
Carbon	45.39	- - - -	37.29
Hydrogen	5.90	- - - -	6.84
Nitrogen	0.40	- - - -	
Oxygen	48.31	- - - -	55.87

Professor Gregory in his outlines of Chemistry (Organic pg 386) observes in reference to this question "There is some reason to think that there is first formed, as in the case of ether a coupled acid or acid salt which is like sulphovinic acid, decomposed by boiling.

According to De Saussure, sulphuric acid & starch do actually form a crystallizible compound. It may not be uninteresting to observe as favouring this view that Braconnet (Berzelius vol VI pp 365) obtained an acid from ligneous fibres while preparing sugar from saw dust or hempen rags. He called this acid "Vegeto sulphuric acid" or "acid of ligneous fibres", starch & ligneous fibres being analogous in composition.

This acid might be considered to be similar to De Saussure's were it not incapable of crystallizing.

We cannot help believing that as sulphuric acid has the property of uniting in a peculiar manner with the elements of water, the latter elements are brought into the presence of the starch in the nascent state and that under these circumstances, one or more at least of its constituents have the property of combining with these elements, in the same way as Hydrogen combines with oxygen by the presence of spongy platinum. This theory ~~of the~~ would explain the formation of an acid from the combination of certain elements of the starch with the with the elements of water, for which the former have a peculiar affinity. This acid combining with the remaining elements of the starch, produces sugar.

The gluten or nitrogenized element in malt and germinated grain in general, has been separated by a peculiar process from the other substances, combined with & called Diastase. It is used in this state to convert Starch into Sugar.

Diastase, says Professor Gregory (Org Chem. page 531) is made by rubbing up malt with a little water, expressing the mixture, adding just enough alcohol to separate the albumen & to assist the liquid in filtering.

The filtered liquid mixed with more alcohol deposits the diastase. It is purified by being repeatedly dissolved in water & precipitated by alcohol.

It is finally dried at a temperature of 100 or 110. Thus prepared, Diastase cannot be a pure compound but it possesses in a high degree the power of promoting the solution of starch, that is, its conversion into dextrine & sugar. One part of diastase is sufficient to convert into dextrine & a little sugar no less than 2000 parts of starch. Starch, when acted upon by diastase in the process of malting, is believed by many to be converted into a substance called Dextrine, which is but a temporary state thro which

~~Starch~~ it passes before it becomes sugar (Gregory outlines pp 497) Dextrine, "observes this author is best obtained "by heating to about 120° a mixture of 20 parts of Starch paste to 1 part of Strong infusion of malt, until iodine ceases to colour the liquid blue. The addition of strong alcohol now precipitates the dextrine as a thick syrup, whilst any sugar remains dissolved. When dried, dextrine much resembles gum from which however it differs in the extreme facility with which it is converted into sugar when warmed with dilute Sulphuric Acid, or infusion of malt, and by not yielding mucic acid, when acted upon by nitric acid.

The Composition of dextrine is the same as starch in fact dextrine is supposed by some, to be the substance which is contained in the grains of starch, included in an insoluble membrane which is burst in the process of conversion into dextrine or solution of starch by means of acid & infusion of malt. Conformably to this theory, I have tried to explain the action of Sulphuric Acid on starch,

Dextrine may be considered as a substance similar to the acid obtained by de Saussure & Braconnet resulting from the primary action of starch on the water united with Sulphuric Acid.

It may be supposed, that owing to an Exchange of Elements between the Starch & the water, the Dextrine may have Entirely the same composition as Starch, its Elements however being arranged in a different order. A similar Theory has been proposed to Explain the various fermentation, it will hereafter be fully discussed.
In regard to the ripening of fruits, various theories have been advanced to Explain the chemical process on which it depends. According to Lindley (Introduction to Botany), it is not produced by the chemical change of the substances contained in fruit when green, but by the change of new substances furnished to it by the tree. When the fruit appears to lose the acid taste which it had in its unripe state, it is because that taste is hidden by the large quantity of sugar, which it receives in ripening. He states that gum & lignine are the only principles, the proportions of which diminish at the same time, it is therefore natural to conclude that it is the portions of these substances which have disappeared that have been converted into sugar. As the lignine contains most carbon it is natural to suppose that it is from it, that the Oxygen takes the Carbon to form Carbonic Acid, that change is indispensible to ripening.

Different substances have the property of exciting this saccharine fermentation. Bouchardat has of late made some very interesting experiments on this subject (Bouchardat, sur la fermentat saccharine ou glucilique Ann de Chemie & Phys XIV pp 61)

According to this Chemist, the substances which he has examined ~~in this hand~~ may be classed as follows.

Diastase
Germinated barley
Albumen of Germinated barley
Putrefied Gluten
Putrefied flesh
Ferment from beer
Unpurified Gluten dry & rounded
Internal membrane of the small intestines of a pigeon
Putrefied barley
New unpurified Gluten
Glutine
Dry vegetable albumen
New Vegetable albumen

The White of Egg, fibrin, glutine, the intestinal & stomachal membrane of a dog, ligneous fibre and hordeine produced no effect whatever.

Bouchardat instituted another series of experiments, to discover what substances prevent this action of diastase upon starch. The starch he made use of was mixed up with 10 parts of water; to 100 grammes of this mixture was added 0.1 gr of diastase or 5 grammes of germinated barley. The various substances, whose effects he wished to examine were carefully mixed with starch jelly; diastase was afterwards added & the temperature of 60° was constantly maintained. The following were the results.

Nitric, Sulphuric, Phosphoric, Hydrochloric, Oxalic, citric & Tartaric Acids put an end to the action of diastase upon Starch. Formic Acid merely caused this action to be less energetic. It becomes slower when arsenious acid is added to the starch mixture while with Prussic Acid it is very weak, and ceases altogether when acetic Acid is employed. Tannin diminished the action without stopping it. Caustic Alkalis prevented the phenomenon from taking place, their Carbonates had a less energetic action & the power of the bicarbonates was still less. Chlorine & Bromine prevent it altogether. The salts of Copper & of mercury prevented the action taking place, nitrate of Silver, Alum & Sulphate of Sesquioxide of Iron had the same property.

Neutral salts, such as sulphates, Phosphates, Chlorides of alkaline & earthy metals had no action. The same with Salicine & Urea; the Alkaloids tended to diminish

the action but only in a slight degree.
Creasote, Alcohol, Æther & Essences did not act as a check to the conversion of Starch into Sugar.
Bouchardat concludes by observing that the globules are in no ways connected with the action of diastase which maintains all its energy when employed as a clear solution. If the action be partially suspended for 24 hours either owing to a diminution of temperature or from a want of power of the diastase, the microscope detects very fine globules floating amidst amorphous masses; but these minute globules have none of the energetic properties of diastase.
In order to determine the action of certain gases upon germination Huber was led to make a series of experiments which have proved very interesting. his Experiments with Oxygen & Nitrogen in reference to that question have already been stated. He next tried the Effects of Hydrogen upon germination. For that purpose he ~~he~~ agitated with lime water, Hydrogen gas, obtained from the decomposition of water by Sulphuric Acid & Zinc, so as to separate from it the slightest traces of Carbonic Acid.
The major part of the grains placed in the gas did not germinate, but the action was excited by the addition of a small amount of Atmospheric air, or of Oxygen gas.

In the latter case, the rapidity of the germinating power was found to depend upon the proportion of Oxygen to the Hydrogen Gas used in the Experiment: the more the proportion resembled that existing between the Oxygen & Nitrogen of the Atmosphere, the greater the germinating power.

He next established a series of Experiments to determine the comparative amount of Oxygen which was to be added to Hydrogen, carbonic acid & Nitrogen in order that germination might take place & he found that carbonic acid is, of the three gases, the one which is most contrary to germination, that Nitrogen came next and finally Hydrogen. Surprised at these results & desirous of explaining why different amounts of oxygen were required in order to induce germination in the three cases, he imagined that Hydrogen & Nitrogen had the property of dissolving a certain amount of Carbon or of combining with it in some unknown manner. The Experiment which he instituted proved that this notion was not unfounded. He mixed some Hydrogen, obtained from the decomposition of Water by Sulphuric Acid with $\frac{1}{3}$rd of its bulk of Oxygen gas. He caused some grains of lettuce to germinate in this gas & proceeded thus till its power of germination became exhausted. He then carefully washed the gas produced by agitating it with lime water, introduced it into the Eudiometer & having also introduced a certain amount of Oxygen, previously washed with lime water he fired it by the Electric Spark. Combination immediately took place, the liquid instantly became turbid from an abundant calcareous precipitate. Carbonic acid must therefore have been produced by the combustion, since it was not found to have previously existed in the liquid, so that carbon must have been dissolved in some way or other by the Hydrogen during the germination of the grains.

Since Nitrogen (adds Huber) produces on germination in similar circumstances, Effects analogous to those produced by Hydrogen, we are induced from analogy to believe that the causes are similar.

Moreover it appears that Nitrogen gas is capable of combining with a greater amount of Carbon than Hydrogen hence in the former case more oxygen is required for germination than in the latter.

This last experiment of Huber is particularly interesting as demonstrating the property of Nitrogen & Hydrogen in Combining with Carbon in the nascent state, keeping it in a kind of latent condition. Should this really be the case, the nitrogen of the atmosphere whose properties are hitherto but little understood, might be supposed to

~~conduce~~ conduce to the germination of vegetables & the fermentation of fruits by combining with the carbon of the vegetables & thus becoming capable of being taken up by the oxygen of the atmosphere.
According to this view the carbon of grains during their germination would have had to undergo a kind of elaborating process before they became fit to be converted into Carbonic Acid.
A new property of the nitrogen of the atmosphere would thus be established, & we might be authorised to conclude that Nitrogen is not an element, but under certain circumstances is combined with carbon without our having the slightest notion of it.
Huber tried the effect of vapour of Ether on germination; it prevented it completely. The vapours of Camphor had the same effect except when much diluted with atmospheric air. Oil of Turpentine & its vapours also prevented germination probably by acting upon the resinous part of the seed. Moreover the volatile oils, combining with oxygen & evolving Hydrogen destroy the property of the atmosphere to excite germination.
Assa Foetida is also an obstacle to germination. Huber has proved that this substance does not alter the nature of the atmosphere, so that the effect must be owing to a peculiar action on the grain itself.

The vapour of vinegar prevented germination; — this acid is known to dissolve the glutinous parts of grain. Ammonia had the same effect —

Putrefying nitrogenised animal substances prevent the germination of grains, perhaps by destroying the oxygen gas necessary to their saccharine fermentation. Mushrooms also tend to diminish the property of the atmosphere in exciting germination, probably from their absorbing a great portion of its oxygen.

If in these experiments mercury was used instead of water to close the receivers, the development of the grains was protracted. He attributed this circumstance to the property of water of slightly absorbing carbonic acid gas, so that the gas produced by germination & which ought to have checked its progress was partly absorbed whilst when mercury was used; the whole remained under the receivers. A thin layer of water being introduced over the mercury, the germinating process continued as if water had been used. —

Alcoholic Fermentation.

This part of our subject is particularly interesting, regarding the various applications to which a knowledge of its nature has led, now comes under consideration.
We shall endeavour to be concise without overlooking those useful & interesting details to which Scientific Essays are often indebted for their success.
What is the nature of this phenomenon.
The Alcoholic Fermentation is that process which is attended with the conversion of a Saccharine solution into Alcohol & Carbonic Acid, when acted upon by a nitrogenized substance & freely exposed to the atmosphere its temperature being slightly raised.
This leads us to consider the various conditions necessary for the production of this phenomena. They are the following:—
1st The presence of a Saccharine Substance to be fermented
2nd The presence of a ferment.
3rd Elevation of temperature with access of air & moisture.

The presence of a Saccharine Substance

The only substances capable of undergoing this fermentation are Saccharine solutions, Saccharine vegetable juices or vegetable juices containing Starch in which Sugar has been developed from the action of gluten at the expense of the former. All vegetable juices containing Cane sugar, Grape sugar, or sugar of mushrooms, begin to ferment a few hours after they have been expressed. It is very likely that the other varieties of sugar, as sugar of Gluten, sugar of Black Juice (Glycyrrhizza Glabra) sugar of Polypodium Vulgare, sugar of Gelatine also undergo this fermentation, but we are not aware whether these Experiments have ever been tried.

Sugar of Milk, may according to circumstances undergo either the Vinous or the Lactic acid fermentation.

Sugars fit to be converted into alcohol & Carbonic acid are incapable of undergoing such modifications before their Extraction from the plants which produce them. Thus:- if ripe grapes be hung up in a dry place they will shrink & lose their water, the juice remaining free from decomposition. This may result from two Causes

1st From the fact that while in its natural envelope the Contained fluid cannot be acted upon the air

2nd From the Curious Circumstance discovered by Fabroni who by an ingenious & careful dissection of a ripe grape observed that the saccharine principle & the gluten was contained in distinct cells; so that the vinous fermentation of the saccharine substance was impossible without the rupture of their cells & the admixture of their contents.

Before any sugar is capable of undergoing the alcoholic fermentation, it is now generally admitted that it must be previously converted into grape sugar. In proof of this it has been shewn that cane sugar i.e. grape sugar minus 1 Eq of water produces after fermentation 53.727 parts of alcohol & 51.298 of Carbonic Acid, together 105.525 the increase of 5.025 parts is due to the 1 Eq of water taken up to form grape sugar into which it is converted before undergoing fermentation. Now grape sugar contains the Elements of 2 Eq alcohol, 4 Eq of CO^2 & 2 Eq of Water & after the fermentation of that sugar, the amount of Carbonic acid & alcohol produced will be seen to contain the same proportions of the Elements found in the Sugar, shewing thereby that they arise entirely from its decomposition.

2nd. Presence of a Ferment.

A ferment is a substance, which added to a saccharine solution, causes it to be converted into alcohol & Carbonic Acid. Colin has shewn by a series of Experiments that any nitrogenized substance may act as a ferment. In regard to wine & beer this has taken the name of yeast.

He has made the following Experiments

1st. 100 grammes of sugar dissolved in 400 grammes of water were placed in contact with 60 grammes of fresh Beef & the sugar was converted into alcohol in three weeks.

2nd. The albumen of an Egg added to a solution of 100 grms of sugar in 500 grammes of water, required more than two months to convert the sugar into Alcohol

3rd. A little less than a litre of urine passed in the morning from a healthy person, was mixed with 100 grammes of sugar & its fermentation was over in a month. In this case supposition we must admit a new ferment, perhaps mucous, or the urea contained in the fluid. He repeated the experiment on the urine of both sexes with similar results. ——

From a set of Experiments on the constituents of blood, he concluded that Serum & especially fibrin induce but very slowly the fermentation of sugar, but the action is much more rapid should either of these be tinged with the colouring matter of the blood. In the Experiment when fibrin was used as a ferment he obtained the first quantity of alcohol (by distillation) after four months, and six weeks later the fluid yielded by the same process a second amount of alcohol equal in quantity & quality to the first. He states that albumen tartarised had a more powerful action as a ferment than when coagulated ~~or~~ putrid & the latter again more than liquid albumen, that gliadine is a degree stronger than Zimone & that Putrefied Gluten ~~induces~~ fermentation more readily than when in the fresh state. Lastly he has shewn, ~~that~~ from Experiments made upon Urine & Pompus that they may both be

made to ferments (act as).—
We are indebted to Dusevenne for some very interesting researches on the substances which may act as ferments & the circumstances under which this action may be checked or prevented; these will be mentioned hereafter.

A ferment may be considered to exist in one of the two following conditions.—

~~1st A ferment may be considered to exist in the following conditions~~

1st A ferment exists & acts without being reproduced as when a mixture of yeast & sugar in solution is made to ferment.

2nd It is not yet a ferment, but can be produced, can act & reproduce itself, as in the case of the juice of a saccharine fruit.

Let us examine these two different conditions which a ferment may assume

1st A ferment exists & acts without being reproduced.

If pure sugar dissolved in water & mixed with a little yeast be exposed to a temperature of from 62° to 70°, after a certain time, carbonic acid will be ~~formed~~ evolved, alcohol found in the fluid, a part of the yeast having disappeared.

From 20 parts of fresh yeast of beer, Thenard obtained after the fermentation was completed, 13.7 parts of an

insoluble residue which diminished to 10 parts when employed in the same way with a fresh portion of sugar.
These 10 parts were white, possessed the properties of woody fibre & had no further action upon sugar.
It is evident therefore that during the fermentation of sugar, the yeast & the sugar both suffered a simultaneous decomposition and disappeared accordingly.
A certain amount of ferment is only capable of modifying a fixed quantity of sugar.
Thenard took equal quantities of fresh yeast of beer one quantity of which he dried & weighed; & the other he added to a solution of a known quantity of sugar, greater than the yeast was capable of modifying.
When the fermentation was over he filtered the fluid, evaporated the filtrate to dryness & from the weight of the residue obtained that of the decomposed sugar; thus he found that 1½ parts of ferment (dry) suffices to cause 100 parts of sugar to undergo a complete fermentation.
In this experiment there remained on the filter a substance varying slightly from the ferment & quite incapable of causing fermentation; when dry its weight was equal to about ½ of that of the dry substance; it was white, insoluble in water, by distillation Ammonia was produced. Thenard afterwards discovered that it was analogous to the Hordein of Proust.

2nd It is not yet a ferment, but can be produced, can act & reproduce itself as in the case of the juice of a Saccharine fruit; thus:—
If any saccharine vegetable juice as that of grapes, gooseberries, ~~currant~~, or grapes be Expressed & the liquid be left undisturbed in an open jar Exposed to a temperature of from 60° to 70°; it will after a few hours assume an opaque appearance, and a slight Evolution of gas will be observable, increasing gradually. The liquid will subsequently become turbid, Effervescing briskly & its temperature will then be found to have risen above that of the surrounding atmosphere. The bubbles of gas appear to come from the precipitate, they adhere to that substance & cause it to rise to the surface of the liquid which is thus covered with a supernatant matter.
The duration of this phenomenon depends on the temperature of the liquid, the quantity & quality of the sugar, present in the fluid, the power of the ferment &c.
It may last from 48 hours, to some weeks.
As soon as the Evolution of gas ceases, the precipitate which floats on the liquid & which constitutes the ferment falls to the bottom & the fluid becomes quite clear.
It is now free from sugar, which has been converted into water & alcohol.

If the fermenting liquid be filtered before the action is at an end, the transparent filtrate after some time reassumes a turbid appearance & the fermentation is established, though less actively than it had been previous to filtration.
If it be filtered when the operation is coming to a close it will not undergo a second fermentation.
In these cases, previous to fermentation the ferment must have existed in the liquid, in a certain latent condition. This subject has been much studied by Leibig, Colin, Thenard & others, who appear to have given a satisfactory explanation of it. —
Many experiments tend to prove, that a ferment consists of two parts, one soluble & one insoluble in water.
The insoluble part observes Leibig does not cause fermentation, for when the yeast from wine or beer is carefully washed under water, without coming into contact with the air, the residue does not produce fermentation. But the soluble part of the ferment likewise, does not produce fermentation.
To explain this difficulty Colin has shewn that in reality we ought to attribute the fermenting power to the soluble part; but previously the decanted solution must be allowed to cool in contact with the air & to remain some time exposed to its action. If introduced into

a solution of sugar when in this state it produces a brisk fermentation; from which we may conclude that in the juice of grapes, the ferment or gluten existed at first dissolved in the liquid, but that by free exposure to air a commencement of oxidation had been effected.

Now Leibig has observed that gluten in solution thus oxidized is rendered insoluble and ——— and Colin has shown that it is only when gluten has become insoluble that it is capable of undergoing fermentation. ⊕ ~~[illegible]~~ a ferment in this case will therefore reproduce itself as long as there is any more sugar to be fermented, & dissolved gluten to be precipitated.

⊕ Accordingly in the above mentioned case, a turbidity took place in the juice of the grape the gluten it contained in solution becoming insoluble and precipitated & only then the [fermen]tation had begun

Seguin contends that though the ferment of fruit is soluble the yeast of beer does not possess that property & he is thus led to deny that a ferment is always soluble. Thenard was the first to prove that any fruit susceptible of undergoing fermentation must contain sugar & a ferment & that they all contained an excess of the latter which precipitated partly during the changes which the sugar underwent.

Taddy has observed that gluten may be decomposed by alcohol which dissolves that part called "gliadine" & leaves an insoluble residue or "Zimonie".

He observed that gluten results from a combination of those two principles

Gregory states that Gliadine is the name given to the viscid ingredient of Gluten, it contains sulphur & approaches in composition to vegetable albumen (Org Chemistry Page 530)
As to the various theories which have been mooted to Explain this action, we shall consider them when discussing the ~~[illegible]~~ theories of fermentation.
Ferments have been repeatedly Examined under the microscope; Before germination says Mr Cagnard Latour it is seen to be composed of globules or corpuscules slightly Ellipsoidal, their margins appear as if lined with appendices somewhat similar to the germs around the mother cell. As soon as fermentation has begun these small disks acquire a certain size, become free, and give rise in their turn to the germs.
Mr Turpin & others have Expressed a similar opinion on this question. — As to its state, a ferment must have an acid reaction; when it is alkaline it loses the property of converting cane sugar into Alcohol & Carbonic Acid, but changes it into Milk sugar & then into Lactic Acid. (Compte Rendu d. l'Ac. d.s Sciences 1r Semestre 1843. P. 943)
As to the Physical & Chemical properties; dried pure yeast of beer is translucent, yellow-brown, horny, hard and brittle in the aqueous state it has no taste or smell; Thenard found that water only dissolved 1/400 part of its weight. (turn over)

If in the moist state it is left undisturbed at a temperature of from 15° to 20° Cent in circumstances which prevent its drying, it begins to putrefy & is at last converted into a mass resembling old cheese. It at first absorbs oxygen & evolves an amount of Carbonic Acid equal to about five times the volume of oxygen absorbed, there is a simultaneous formation of acetic acid.
By distillation; yeast yields the same products as gluten. Thenard from 100 parts of ferment obtained

Water —	20.10
Empyreum Oil —	16.40
NH_4OCO^2 —	13.20
Gaseous substances —	4.10 $\frac{1}{3}$ of CO^2 $\frac{2}{3}$ combust
Carbon —	35.40

Dilute acids dissolves a considerable portion of ferment. Nitric Acid decomposes it with evolution of Hyponitrous or Nitrous Acid gas & produces a fatty substance analogous to tallow. Potash dissolves ferment with evolution of Ammonia which would lead to the conclusion that it contains ammonia, merely set free by the alkali, but gluten and albumen dissolve with evolution of Ammonia (Berzelius)
According to Döbereiner the aqueous ferment triturated

with pounded Cane sugar becomes a mass which is transformed into a translucent syrup; this Effect is however purely mechanical. Ferment if in the dry state still contains a sufficient amount of water to convert sugar into a syrupy fluid. This syrup is a medium in which the ferment & the sugar may be kept in an inert condition for a considerable time without losing their respective properties.

The third condition required for alcoholic fermentation is the presence of Oxygen gas.

Gay Lussac has satisfactorily shown that if a grape be Expressed in a gas quite free from Oxygen, the fermentation of the juice does not take place.

He Expressed the juice of grapes under a jar of Hydrogen there it remained for a month, unaltered, on the other hand another quantity of the same juice expressed in the atmosphere & kept under another jar next to the former, underwent fermentation as usual.

Having introduced in to the jar of Hydrogen a small quantity of atmospheric air, the juice which it contained began to ferment. He obtained a similar result by Expressing grapes ~~evaporating~~ in the Barometric vacuum, & it remained unaltered for a long time, but on the introduction of air or oxygen gas, fermentation immediately Ensued. Thus the amount of oxygen necessary to excite fermentation is very small and the active person without requiring a new supply of that gas. This enables us to understand why grape juice expressed in the air is capable of fermenting in vacuo & under closed jars. Gay Lussac filled a bottle with the juice of grapes, expressed in the air, sealed the stopper & left it for a few minutes exposed to a heat of about 100 Cent, in this case the oxygen being in some way absorbed, the fluid did not undergo fermentation.

~~Gay Lussac~~ He kept other vegetable juices quite unaltered for a considerable time in stout bottles by heating them once a day for a few ...

It is on this principle that ~~[illegible]~~ Apert's method for preserving fruit is founded, which process is now extensively adopted.

This property of the oxygen in the atmosphere of being absorbed or rather combining with some part of the juice is very singular and leads us to believe that at 212° the carbon of the fruit is capable of being oxidized. It will be remembered that the Romans, to preserve grapes used to cover the stems of the branches with tar, a substance containing a considerable supply of carbon which perhaps acted by yielding carbon to the oxygen of the air. Pliny tells us that grapes in order to be preserved were inclosed in glass bottles, the stalks of the branches having been previously dipped into starch. (See ...

It has been thought by Döbereiner & other chemists that carbonic acid, free from oxygen had the same power of inducing fermentation as oxygen gas.

Berzelius observes that, were this true, it should appear that the Oxygen of the Air would be owing its property of exciting fermentation to the carbonic acid which it produced and that to the latter only belonged the power of inducing such changes as conduced to fermentation. But we cannot tell how far the Carbonic Acid of Döberiner was free from oxygen; however, Henry had shown long before him that must of beer undergoes fermentation when saturated with Carbonic Acid gas.

3rdly It was believed for a time that the action of the atmosphere & even of the ferment might be ~~r~~eplaced by the galvanic battery. Gay Lussac had caused the juice of the grape to undergo fermentation by that means, preventing any access of atmospheric air, and Colin also induced this action by the same process, in a liquid half of which having previously been set aside, had not begun to ferment after the lapse of two months.

But says Berzelius ~~the~~ the action of the battery is owing rather to the evolution of Oxygen gas which it produces, since electricity acting upon a solution of pure sugar induces in it no change. Schweigger has attempted to explain this theory by supposing that the ferment uniting ~~with~~ sugar and water gave rise to a number of small electrical couples suspended in the liquid. This electrical theory will be again considered along with the different views which have been advanced to Explain fermentation.

Lastly Heat & Moisture are the two other conditions necessary to produce fermentation. It is believed to be necessary for the decomposition of the yeast & for forwarding its action upon the fermenting substance.

The most favourable temperature for the fermentation of malt is from 60° to 70° It can hardly be said to take place at a temperature lower than 50°. Thus in the temperate climates, as France, Switzerland &c, when the autumn happens to be cold, the wine is always of a very inferior quality, caused by the want of the necessary heat for its complete fermentation.

Moisture on the other hand is considered indispensable to this process in yielding Oxygen to the yeast, thus allowing it to undergo a rapid decomposition. Thus dry or fruit may be kept for an indefinite period and dry raisins, figs, pears &c are always abundant in the market & are sold at a comparatively low price

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Products of the Alcoholic Fermentation.

Having described the phenomena which attend this fermentation & examined the conditions which are indispensible to their performance, we shall now proceed to consider the various products which result from this action; the first is Alcohol.

Intoxicating beverages owe this property to a greater or less amount of Alcohol produced in a saccharine liquid after its fermentation. This Alcohol may be obtained pure by ~~the~~ distillation. This process is practised on a large scale in distilleries from whence various spirits are obtained, as brandy, rum, whisky &c

But does this alcohol owe its production in the liquor to the process of distillation or did it exist there previously?

Some very interesting experiments were performed by Brande in 1811 & related in the Philosophical Transactions of that year prove beyond doubt that the alcohol was in the fermented fluid previous to its distillation.

It was formerly the general opinion among chemists, though contrary to facts, that alcohol was principally a product of distillation. Thus Fabroni did not succeed in separating alcohol by saturating wine with subcarbonate of Potash although by the same means he could detect very minute proportions of alcohol which had been previously added.

Brand in order to obtain satisfactory results used wines to which no spirit had been added.
Having distilled a certain amount of wine from which he had previously ascertained that subcarbonate of potash separated no alcohol, he mixed the distilled liquid (which contained a pretty large proportion of pure spirit he could separate by the above reagent) with the residue in the flask, and on the addition of the reagent, no alcohol was detected.
2nd Four ounces of dry & warm subcarbonate of Potash were added to 8 fluid oz of Port wine which was previously ascertained to afford by distillation 20 pct of alcohol, sp gr 0.825 at 60°. In 24 hours the mixture had separated into two distinct portions, at the bottom of the vessel was a strong solution of the subcarbonate upon which floated a gelatinous mass of such consistency as to prevent the escape of the liquor beneath when the vessel was inverted & which appeared to contain the alcohol of the wine with the principal part of the extract, tan, & colouring matter, some of the subcarbonate & a portion of water. To seven fluid ounces of the same wine he added 1 fluid oz of alcohol & the same quantity of the subcarbonate of Potash as in the last experiment, but after 24 hours had elapsed no distinct separation of alcohol had taken place.
When 2 fluid oz of alcohol were added to vj fl ℥ wine

& the mixture allowed to remain undisturbed for the same length of time as in the last experiment, a stratum of impure alcohol of about ¼ inch in thickness separated on the surface.

The addition of 3 fl ʒ of alcohol to 5 fl ʒ of water constituted a mixture from which a quantity of spirit readily separated on the surface when the sub-carbonate was added & the gelatinous compound sunk nearly to the bottom, there being below it a strong solution of sub=carbonate of Potash. I Brand now considered that if the spirit afforded by the distillation of the wine, was a product & not an educt, by performing the distillation at different temperatures, various proportions of spirit should be obtained, In order to prove this point he dissolved in 8 fluid oz of the Port wine in the former experiment 4 dried muriate of lime by this addition the boiling point of the wine which is 190° F. was raised to 200° The solution was placed in a retort, in a sand bath & was kept boiling until 4 fluid oz had passed over into the receiver, the Sp. Gr of which was 0.96316 @ 60 F°

The experiment was repeated, 8 fl oz wine without addition & the same quantity distilled over as in the last experiment, the sp gr in this case was found to be 0.96311

8 fluid oz wine were distilled in a water bath, when 4 fluid oz had passed over, the heat was withdrawn the sp gr of the liquid in the receiver was 0.96320.
The same quantity of wine as in the last Experiment was distilled at a temperature not exceeding 120° Ft this temperature was kept up from 4 to 5 hours for 5 successive days at the end of which period 4 oz having passed into the receiver its sp gr at 60° was ascertained to be 0.96314.
We may conclude from these results (adds Brand, that the proportion of alcohol is not influenced by the temperature at which wine is distilled and as a conclusive proof that alcohol exists, previous to distillation.
Brand succeeded by the artificial freezing of large quantities of wine to separate the alcohol, the water being the first to freeze, because adds Brand in some countries this method is employed for adding strength to wine.

2nd Carbonic Acid.

Along with the presence of alcohol in a liquid which has undergone the vinous fermentation, a considerable evolution of Carbonic Acid may be observed.
Every particle of the liquid appears to disengage Carbonic Acid which rises in an infinite number of bubbles, bursting as soon as they reach the surface.

During the fermentation of the juice of grape the phenomenon is most conspicuous. Different means have been employed to prevent the escape of this gas, as in so doing the aroma of wine has been found to improve and its alcoholic strength increased. The carbonic acid therefore must have carried away from the must or fermenting liquid a considerable amount of alcohol. Chaptal, has shown that by placing vessels of pure water above the fermenting vats after the vintage that this water absorbed carbonic acid during the three or four first days and by enclosing this liquid in open bottles left undisturbed for about one month vinegar of tolerably good quality might be obtained.

Simultaneously with the formatation of vinegar he observed in the fluid an abundant flocculent precipitate analogous to woody fibre.

If the water used for that purpose instead of being pure, contained solutions of earthy sulphurets the acetification was accompanied with a smell of Sulphuretted Hydrogen, resulting from the decomposition of the Sulphuret. This experiment suffices to prove says Chaptal that the Carbonic Acid evolved, deprives the liquid of a certain amount of Alcohol & of a small quantity of ferment, so that these two elements necessary for the acetic fermentation, coming in contact with water

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freely exposed to the atmosphere produced vinegar.
It should appear that this alcohol is dissolved in the carbonic acid, & does not volatilize with it from the action of heat. Humboldt has shown this by collecting the froth of Champagne under receivers surrounded with ice, the cold caused an immediate deposit of alcohol upon the sides of the receivers. It is therefore this alcohol which communicates to the gas arising from fermenting wines that peculiar odour which is so conspicuous in Champagne & in most other frothy wines.
Gay Lussac showed from a series of ingenious ~~[illegible]~~ calculations that wine supposed to be composed of 51.34 parts alcohol & 48.66 parts of Carbonic acid has lost by fermentation 1/600 th of the alcohol which would have been produced had it not been for this loss.

3rd. Oenanthic Ether.

The flavour or aroma of wines, which they have acquired by fermentation is owing, according to Leibig, to an ether of an oily nature, which has been called Oenanthic Ether. It is also ascertained that the smell & taste of Brandy from Corn & Potato is owing to a peculiar oil, or oil of potato spirit, which bears a near analogy to alcohol. These products contain less oxygen than sugar or gluten but are remarkable for their large proportion of Hydrogen.

The substances in wine to which its taste & smell are owing are generated during the fermentation of the juices of such grapes as contain a certain quantity of Tartaric Acid

Thus, the grapes growing near the Rhine, which produce wines of such fine bouquet & especially those which ripen very late & scarcely ever completely have the strongest bouquet & contain proportionally a large proportion of Tartaric Acid. It is evident from these facts observes Leibig that the acid of wines & their characteristic perfumes have some connection for they are always found together.

On the other hand it is known that the Brandy made from Potato Starch which has been converted into Sugar by dilute Sulphuric Acid is completely free from the potato oil, so that this oil seems to be resulting from a change suffered by the cellular tissue of potatoes during their fermentation.

It is curious that the addition of hops to fermented grains is an insuperable obstacle to the production of this oil, so that beer is completely deprived from it, perhaps the action of hops similar to a certain extent to oil of mustard which arrests the action of yeast so that the former should diminish its volume.

Leibig believes that some aromatic substances when added to fermenting liquors are capable of producing very various modifications in the products generated. The greatest part of the oil of Brandy made from Corn consists of a fatty acid, identical in Composition with Œnanthic acid but different in properties (Mulder) It is formed in fermenting liquids, which if they be acid contain only acetic acid, a body which has no influence in causing other bodies to form ethers.

The Oil of Brandy made from potatoes is formed in considerable quantity in fermenting liquors possessing an alkaline reaction, under circumstances, consequently when it is incapable of combining with an acid.

It may be mentioned that the Centaurium Minus a plant destitute of smell, when exposed to water to a slightly elevated temperature, ferments and produces by distillation an ethereal, oily substance of great volatility which excites a pricking sensation in the eyes & a flow of tears (Büchner) but this is rather a separate fermentation which is unconnected with the alcoholic. —

Let us now enter into a few details concerning the causes which may retard or accelerate alcoholic fermentation This subject has been satisfactorily investigated by Quevenne whose experiments are the following: —

1st. Yeast exposed for a long time to a temperature of 212° lost a good deal of its power, but left a whole night at a temperature of 14° Cent it reassumed its activity.

2nd. Six drops of essence of turpentine being mixed with 60 grammes of water and 20 grains of sugar & 1 gramme of yeast no action took place. –

Lucomne discovered that powerful mineral acids did not favour fermentation. thus: —

3rd. If to the above mentioned amount of water, yeast & sugar, 6 drops of Sulphuric ~~acid~~ of Nitric or of Hydrochloric acid, be added, no fermentation ensues, but this action is merely delayed if Phosphoric Acid be added in the same proportions. 4th. A dose of 30 Centigrm of Arsenious acid (about 4½gr) did not prevent fermentation, but only restrained its activity.

5th Certain organic Acids are favourable to fermentation when not in excess, but this process appears to be checked or at all events retarded by the presence of other acids of this nature. Experiments made with the above mentioned proportions of water, sugar & yeast by the addition of various amounts of acetic acid gave the following results.

6th. Fermentation took place when from 4 to 10 gtts of this acid were used, but 20, 40 or 80 drops arrested it. The addition of Lactic Acid in similar proportions produced analogous results. 60 Centigrms or 9.3 grs tartaric Acid or Citric Acid having been added, the action was not altogether checked but went on slowly.

7th. Tannin appears to have no effect either way on this phenomenon.
8th. The presence of Oxalic Acid invariably brought fermentation to a stand still.
9th. Prussic Acid when added to the above mentioned proportions of yeast, sugar & water, produced similar results.
Alkalis are far from being favourable to fermentation but these effects may be changed by certain modifications which arise in the liquid.
10th. 30 ~~Grms~~ Centigrms of a concentrated solution of caustic Potash, having been added to the liquid it was rendered decidedly alkaline. No fermentation endured for a whole day but it commenced after 36 hours and continued with renewed vigour. The liquid had become P.t Neutral & when the fermentation began it was found to be slightly acid
11th. As for the action of Salts on a fermenting liquid, Cream of Tartar, Acetate of Potash, & Sulphate of Soda produced no decided effect. The addition of 12.6 gr Strychnine rendered the liquid slightly alkaline, fermentation did not take place, but after the liquid had become acid it went on with the usual activity.

Made a few more researches upon the properties of yeast, & the circumstances which may check or promote fermentation but which our limited space does not allow us to enter upon.—

– Lactic Fermentation. –

When milk becomes sour, and in the fermentation of several vegetable juices as well as in that of a solution of sugar in contact with casein, lactic acid may be detected in the fermented fluid; this same acid has also been found to result from the fermentation of Beet Roots, Carrots, Turnips, of rice Water and in the infusion of bark used by Tanners. – (Turner's Org. Chemistry P. 983)

When exposed to the atmosphere, milk undergoes a particular change; it is generally believed that its casein is decomposed which induces the sugar of milk to be modified; in this way a small quantity of lactic acid is generated, so that the casein not yet decomposed is caused to coagulate; the decomposition of the casein continues however at the expense of the atmosphere till at last the whole of the sugar of milk is converted into Lactic acid. – ~~[illegible]~~. If the acid be neutralised and fresh sugar added it will undergo the same change as long as there remains any casein. In making the better kind of Cheese the milk instead of being allowed to coagulate spontaneously is coagulated by contact with water in which part of the lining membrane of the stomach has been infused. This infusion called Rennet acts by containing albumen or gelatin in a state of decomposition. –

In this case casein acted as a ferment inducing a peculiar change in the sugar, showing that a fermentation depends more or less on the nature of its ferment.

This conversion of Cane sugar or of sugar of milk into Lactic acid when in contact with Casein is easily understood for 1 eq. Grape sugar $C_{12} H_{12} O_{12}$ or 1 eq. Cane sugar plus 1 eq. of water is exactly equal to 2 eq. of Hydrated Lactic acid $2(C_6 H_6 O_6)$.—

Dumas (Traité de Chimie Vol. VI) observes that Diastase deserves a peculiar notice as a ferment capable of generating the lactic fermentation. Diastase recently prepared or rapidly dried converts starch into Dextrine and Dextrine into sugar; but Diastase kept for a few days in moist atmosphere undergoes a modification and becomes a ferment capable of generating in dextrine or starch the Lactic fermentation.— Thus in order to obtain a considerable amount of Lactic acid it is merely necessary to moisten germinated barley and to keep it for two or three days freely exposed to the atmosphere, to mash it in water and lastly to allow it to stand for two or three days more in a temperature of 25° to 30°C. If the liquid should now be saturated with lime a lactate of Lime is obtained which is made to crystallize in alcohol in order to separate from it any dextrine or earthy phosphates. Lastly let me mention a curious circumstance (Compte Rendu de l'acad. des Sciences 1re Semestre 1843) that when a ferment is alkaline it is no more capable of converting cane sugar into alcohol or carbonic acid but changes it into sugar of milk and from thence into Lactic acid.—

The various circumstances which arrest or impede the alcoholic fermentation have a similar influence on that which we have been considering.—

Viscous Fermentation

This is a curious modification which certain saccharine juices as those of carrots, onions, Beetroot and others are liable to undergo when exposed at a temperature of from 86° to 107° F.— White wine may also undergo a spontaneous change thereby becoming viscous and oleaginous which is attributed to a similar phenomenon. The fluent products of this fermentation are <u>Mannite</u> <u>Lactic acid</u> and a viscid substance resembling <u>gum</u>.—

Mr. Desfosses has observed that in order to induce this viscous fermentation it suffices to boil yeast with water and to dissolve sugar in the previously filtered decoction. The fluid assumes the consistence of a thick mucilage and there may be observed a slight evolution of carbonic acid and of Hydrogen gas. Peligot informs us that there is developed in the liquor a globuliform ferment very analogous in appearance to yeast which may excite the viscous fermentation in saccharine juices exposed to a favorable temperature. Gluten also deposits in boiling water a substance which readily generates that kind of fermentation. When the action appears to be at an end, if carefully washed yeast be added, the alcoholic fermentation ensues which causes the sugar unaffected by the preceding process to disappear. —

Hydrochloric, sulphuric, sulphurous acids and even alum prevent this phenomenon by precipitating the ferment, François has inferred from this fact that the best means to prevent the viscid consistence of wines is the addition of small quantity of tannin which precipitates the ferment. —

According to Dumas Gluten in the must of wine exists under two forms. One soluble in water in the presence (à la faveur) of alcohol and of tartaric and which is the ferment capable of exciting the viscous fermentation; the other precipitating and constituting the ferment which generates the Alcoholic fermentation, so that gluten contains the elements of two ferments, of one which produces wine and of another which alters its nature. The art of the Wine Maker consists in precipitating the obnoxious ferment without altering the other.

Butyric Fermentation

If 14 parts of Cane sugar be dissolved in 60 parts of water, and if 4 parts of moist cheese be added with a sufficient quantity of prepared Chalk the whole being kept at a temperature between 77° & 86° F.; the liquid will after a short time become quite thick with crystals of Lactate of Lime, but if the action of the caseous ferment be continued at a temperature of 100° or 105° F lactate of lime is no more produced but a butyrate of Lime appears in large quantity. —

This change is said to be accompanied with the evolution of Carbonic acid and Hydrogen. Now Hydrated Butyric acid, observes Turner, is $C_8 H_8 O_4$ while hydrated Lactic acid is $C_6 H_6 O_6$, and therefore we must suppose 1 eq. Butyric acid to be derived from 2 eq. Lactic acid $C_{12} H_{12} O_{12}$ that is 4 eq. Carbonic acid & 4 eq. Hydrogen. This is, he adds, on the supposition which appears probable that the Lactic acid is the sole source of the Butyric acid, and also that Lactic acid is the chief or only product of the formation of sugar in contact with Casein.—

This throws some light on the formation of butyric acid in the body of the Cow and other animals, probably from the sugar or starch of their food being found in butter along with other analogous volatile, oily acid which have not yet been artificially formed from sugar. Thus this principle when fully investigated may lead to the artificial production of oily or fatty matters in general; it has been shewn by Liebig and others that these are certainly, in part at least, formed from sugar in the animal organism by a separation of oxygen.

Acetous Fermentation

This is the phenomenon which accompanies the conversion of any liquid, which is capable of the vinous fermentation, into vinegar or acetic acid. Sugar is ~~theo~~ present in all those fluids which is first converted into alcohol, and then into Acetic acid.

This process is much at variance with fermentation and resembles it merely from the necessity of the presence of a ferment and of atmosphere. —

Dœbriner from the fact that vapour of alcohol in contact with Platinum powder caused it to become red hot and was itself converted into acetic acid shewed that Oxygen is essential in the experiment; and he further proved that 1 atom of ~~oxygen~~ alcohol absorbed 4 atoms of oxygen to form acetic acid. —

But before alcohol is converted into vinegar, it loses 2 eq. Hydrogen thus becoming aldehyde, and the latter in combining with 2 eq. water is converted into acetic acid. — Dumas adds that an oxydation similar to that which alcohol undergoes in presence of spongy platinum takes place in half empty casks containing wine, that the atmosphere acts on that portion of the liquid which rises on the sides of the casks from the capillary attraction induced by the pores of the wood which thus becomes oxydised and converted into vinegar. —

Liebig's theory regarding that phenomenon is that the ferment acts by contact communicating mecanically its own state to the alcohol. — When the precipitation of the ferment is produced at a temperature at which the alcohol is not oxidised, the fluid by the removal of those substances loses the property of passing into Vinegar at a higher temperature

This often happens in wine, and Bavarian beer which has been made to ferment at a low temperature till all the matters which favour acetification have been rendered insoluble, is prepared on this principle.—

In regard to the action of the ferment I may observe that the Oxygen it takes up in the act of decomposition assumes the nascent state which might enable it to combine with the alcohol; the ferment possessing in this case properties similar to those of platinum, thereby bringing oxygen in a nascent state and causing it to combine with the alcohol. This phenomenon however is rather an example of putrefaction than of fermentation.—

Benzoic Fermentation

In this case, a neutral nitrogenised substance having no action upon the animal system and contained in the oil of bitter almonds is made to undergo a curious modification. Among the new product may be noted Hydruret of Benzoile and Hydrocyanic acid constituting together the essence of bitter almonds which possesses violent poisonous properties.—

Robiquet Wöhler and Liebig have studied very minutely this phenomenon and their experiments have revealed the important fact of the spontaneous production by artificial means of certain volatile oils not preexisting in plants, which are capable of arising from the products of their decomposition.—

Bitter almonds contain a large quantity of an albuminous or caseous matter called emulsine or synaptase along with an oil, the oil of Almonds very similar to olive oil, and 4 or 5 per % of a substance called Amygdaline.. — If the Amygdaline be removed by boiling alcohol, the residue when distilled with water does not yield a trace of the volatile oil of bitter almonds, again if the residue of bitter almonds after the fat has been pressed out be heated to such a point as to coagulate the emulsine before water is added, the distillation also yields no volatile oil although the Amygdaline be present; but if both Amygdaline & emulsine be present in water and the mixture distilled, the volatile oil of bitter almonds will be obtained.

These facts show that the production of this oil depend on the presence 1st of Amygdaline, 2dly of soluble emulsine; before water is added the distillation yields no volatile oil even although the Amygdaline be present, but after the addition of water the oil is dissolved as it is formed and the amygdaline disappears in a short time.. — If the expressed oil of almonds be thrown into boiling water the synaptase coagulates and can then produce no change in the amygdaline. To obtain the full proportion of oil, 1 part of expressed almonds should be macerated for 24 hours with 20 parts of water at about 102° F. and then distilled. —

In the above remarkable decomposition, observes Gregory, we have a very beautiful example of a metamorphosis in which the elements of two bodies take a share, but as the whole of the products are not yet exactly known and even the composition of emulsion or synaptase is uncertain, we cannot explain the whole changes with precision. We know however that from 1 eq. amygdaline: $C_{40}\ NH_{27}\ O_{22}$, the following compounds may be derived. —

1 eq. Hydrocyanic acid	$C_2\ NH$
2 eq. Hydruret of Benzoile	$C_{28}\ H_{12}\ O_4$
1/2 eq. Sugar	$C_6\ H_5\ O_5$
2 eq. Formic acid	$C_4\ H_2\ O_6$
7 eq. Water	$H_7\ O_7$
1 eq. <u>Amygdaline</u>	$C_{40}\ NH_{27}\ O_{22}$

Also 1 eq. of <u>Amygdalinic acid</u> (Prepared by boiling amygdaline with Baryta) $C_{40}\ H_{26}\ O_{24}$, may yield. —

3 eq. Formic acid	$C_6\ H_3\ O_9$
2 eq. Hydruret of Benzoile	$C_{28}\ H_{12}\ O_4$
1/2 eq. Sugar	$C_6\ H_5\ O_5$
6 eq. Water	$H_6\ O_6$
1 eq. Amygdalinic acid	$C_{40}\ H_{26}\ O_{24}$

Now we can trace all these products among the results of this transformation and it is probable not only that there is more sugar than can be accounted for by the amygdaline but also that other products not yet known are formed. The emulsine or synaptase which produces this remarkable change in amygdaline in which it itself participates contains nitrogen, is soluble in water, coagulable by heat, and in short very analogous both to albumen and casein.–

Regnault (Cours de Chimie Vol. 2. P. 765) observes that the action of synaptase on amygdaline is similar to that of yeast upon sugar, and that it is perfectly analogous with the various phenomena which are understood to constitute fermentation.–

In short, it is now generally admitted ~~that~~ that this curious action is a species of fermentation the changes of which we are, ~~as yet~~ but very little acquainted with.–

Pectic Fermentation

The juice of any ripe pulpy fruit when boiled for a certain time, and otherwise in particular circumstances generates a gelatinous substance which have been considered as derived from an element insoluble in water which has been called Pectose. This substance is so perfectly mixed with the cellulose which constitutes the cell walls of the fruit that no means have been detected to effect its separation. Pectose possesses the curious property of being converted into a substance soluble in water called Pectine when acted upon by acids and heat. This character serves to distinguish it from cellulose which is endowed with no such property. Pectine exists in ripe fruit, but it is only to be found in those green fruit which have been subjected to heat, the vegetable acid they contained acting along with an increased temperature. —

In the vegetable tissues which contain Pectose may be found also another peculiar substance called Pectase (Regnault V.2. P566) which is capable of acting upon Pectine much in the same way as yeast acts upon Sugar. This pectase may be separated by the action of alcohol which precipitates it from the juice of expressed carrots, the Pectase has thus become insoluble in water but its power of modifying Pectine has not been altered. —

This Pectase possesses the property of converting Pectine into a gelatinous substance insoluble in cold water without taking any part (chemical) in this modification. This phenomenon has been called the Pectic Fermentation and is analogous to the other varieties of fermentation which have been already considered. This process may take place without the action of the atmosphere and is attended with no evolution of gas.—

The temperature the most favourable to this fermentation is 86° F. (30°C).—

Pectase is not crystallisable, left in water for two or three days, it is rapidly decomposed, becomes covered with mould and loses the property of exciting this Pectic fermentation. Its action upon Pectin also disappears when it is left for a certain time in boiling water.— Pectase is found in vegetables sometimes in a soluble sometimes in an insoluble state. Carrots and Beet-Roots contain soluble Pectase; it is insoluble in acid fruit.—

When Pectase is added to a solution of Pectine, the latter is soon converted into a gelatinous acid sparingly soluble in water this is Pectosic Acid. This acid is also obtained by acting upon Pectine kept cold, with a dilute solution of Potash, Soda, Ammonia or of alkaline carbonates. It is necessary to avoid concentrated alkaline solutions and to prevent their action from being prolonged for the Pectosic acid would be converted into a new acid Pectic acid. Thus we are led to believe that under the

influence of heat and of vegetable acids existing in fruit, the pectose is first converted into Pectine and the latter is changed into Pectosic acid, (which differs from the pectine merely by its containing less water, ~~than~~ of viz. Pectine . . . $C_{64} H_{40} O_{56} . 8HO$ –
Pectosic acid . . . $C_{32} H_{20} O_{28}$ $3HO$)
by the presence of Pectase, and that if the Pectase and that if the latter be allowed to act for a certain period this acid is converted into Pectic acid whose formula is
Pectic acid $C_{32} H_{20} O_{28} . 2HO$
only slightly at variance with Pectine. $C_{64} H_{40} O_{56} . 8HO$.–

It is necessary to increase gradually the temperature for if the juice were to be suddenly exposed to a heat of 212° F. the properties of the Pectase would be annihilated.–

–. Putrefaction .–

Putrefaction has often been considered as a species of fermentation and described as the Putrefactive Fermentation, but Liebig justly observes that there exists a marked difference between these two phenomena. For inst: in the alcoholic fermentation the yeast is putrefying, and the sugar is fermenting. –

A nitrogenised substance is peculiarly prone to undergo putrefaction. Nitrogen being of a very unstable nature the bodies in the constitution of which it enters are particularly liable to decompose, or to a transformation of their atoms as fulminating Mercury, as Iodide or Chloride of Nitrogen and all fulminating compounds. All other azotised substances acquire the same power of decomposition when the elements of water are brought into play. – When the decomposition of such substances is effected with the assistance of water their nitrogen is invariably liberated in the form of ammonia. This is a fixed rule without exception whatever may be the cause of such decompositions; Ammonia is therefore the most stable compound of nitrogen; but besides nitrogen, azotised compounds contain a certain amount of Carbon which has a great affinity for Oxygen, thus we have two elements which mutually share the elements of water, there are two opposite affinities in play which mutually strengthen each other's action.

Thus Hydrated Cyanic Acid contains Carbon, Hydrogen, Nitrogen and Oxygen in such proportions that the addition of a certain quantity of the elements of water is exactly sufficient to cause the Oxygen contained in the water to unite with the Carbon and form

Carbonic acid, and the hydrogen of the water to combine with the Nitrogen of the Acid to form Ammonia. The most favourable circumstances for a complete transformation are therefore associated in these bodies and it is well known the disunion takes place at the instant in which the cyanic acid and water are brought into contact the mixture being converted into Carbonic acid and ammonia with a brisk effervescence. —

This decomposition may be considered as the type of the transformation of all azotised Compounds it is Putrefaction in its simplest and most perfect form because the new products Carbonic acid and ammonia are incapable of further transformations. (Liebig's Chemistry of Agriculture and Physiology P. 297). —

Putrefaction assumes a totally different, and much more complicated form when the products at first formed undergo a further change. In this case the process consists of several stages of which it is impossible to determine when one ceases and the other begins. Thus Cyanogen only consists of two elements; Carbon and Nitrogen and yields in contact with water 8 totally different Products. —

In Fermentation the transformation is the transposition of the elements of a complex compound by which new compounds are produced with or without the assistance of water. In the products newly formed in this manner either the same proportion of the component parts which were contained in the matter before transformation are found or with them an excess consisting of the constituents of water which had assisted in promoting the disunion of the elements.

Putrefaction consists of the transposition of the atoms of two or more complex compounds by which the elements of both arrange themselves mutually into new products with or without the cooperation of the elements of water. In this kind of transformation the new products contain the sum of the constituents of all the compounds which have taken a part in the decomposition. —

In other terms in Putrefaction the elements of the substance which exits putrefaction combine with those of the putrefying body; but in fermentation the ferment takes no chemical part whatever in the modifications which the fermenting substance undergoes. —

Many phenomena have been erroneously considered as fermentations which were in fact examples of Putrefaction; thus Urine, Bil and other Nitrogenized substances when left for a certain time exposed to the atmosphere have been considered as modified by fermentation, when they had merely undergone a beginning of putrefaction. —

After having given a cursory view of the various fermentations now admitted by Chemists I shall proceed to examine in succession in the following pages the numerous theories which have been proposed to explain these phenomena. —

Theory of Fermentation.

The observer who has examined minutely into the nature & causes of a phenomenon is unavoidably led to form an opinion as to their mode of action.

Thus having endeavoured to present a concise and clear statement of the causes which promote fermentation & of the nature of this phenomenon, we now proceed to consider the various theories which have been advanced to explain it.

I am induced to mention at the outset a certain number of conditions whose existence of these theories necessarily require

1st. This theory must account for every one of the conditions which have been mentioned as necessary for the phenomenon to take place.

2nd. It must explain in a satisfactory manner the changes which occur in the fermenting liquid.

3rd. It must convey a clear notion of the substances resulting from the modifications of those which have undergone fermentation.

Our present ~~object is to~~ intention is to proceed to a severe & minute enquiry into this interesting question & to reject any theory which is incompatible with the above named conditions.

It is now generally believed that Fermentation is the phenomenon, which, accompanies certain modifications some vegetable non azotized substances are liable to undergo when in presence of an exciting agent or ferment & freely exposed to air heat & moisture.
This definition is merely ~~as~~ a statement from observed facts which has therefore no ground for objection
Thus we have purposely confined this essay within fixed limits; there are however certain curious phenomena which are slightly at variance with ordinary chemical laws which we may perhaps be allowed to consider first. They will afford us useful documents regarding some of the theories which we shall dwell upon.
Thus: — If a current of Hydrogen be directed on a fragment of Spongy Platinum it combines with Oxygen, supposed to be condensed within the Pores of the Platinum. Porous bodies, as Charcoal, Pumice Stone Powdered Glass &c possess the same power, of causing a combination of Hydrogen with the Oxygen of the atmosphere
The Platinum has been considered to be endowed in this case with new properties called Catalytic, i.e. it disposes the Oxygen of the atmosphere to combine with Hydrogen, without ~~of~~ itself taking any part in the action
We might adduce many other cases where platinum has a similar action, thus it may induce the oxidation

of alcohol & its conversion into vinegar.

Again, if a piece of platinum foil be exposed at the aperture of a jar filled with a mixture of Oxygen & Hydrogen; the combination of these gases will take place, causing a deposit of aqueous vapour on the platinum.

Leibig observes; Peroxide of Hydrogen is decomposed by all substances capable of attracting oxygen from it & even by contact with many bodies such as platinum or silver which do not enter into combination with any of its constituents. The Platinum or Silver was again in this case endowed with a Catalytic force

Leibig further says, A remarkable action of Peroxide of Hydrogen has attracted much attention because it differs from ordinary chemical phenomena

This is the reduction which certain oxides suffer by contact with this substance at the instant at which the oxygen separates from the water. The oxides thus easily reduced are those of which the whole or part at least of their oxygen is retained merely by a feeble affinity such as the oxides of silver & of gold, & peroxide of Lead.

Oxides very stable in composition effect the decomposition of Peroxide of Hydrogen without experiencing the smallest change, but when oxide of silver is employed to effect the decomposition all the oxygen of the silver is carried away, with that evolved from the Peroxide of Hydrogen & as a result from the decomposition, water & metallic silver remains. When peroxide of lead is used for the same purpose, half its oxygen escapes as gas.

If we add to Peroxide of Hydrogen, Sulphuric acid & then Peroxide of Manganese in the state of fine powder much more oxygen is evolved than the compound of Oxygen & Hydrogen could yield and the solution will be found to contain a salt of the protoxide of manganese so that 1/2 the oxygen has been evolved from that metal.

In this case the Peroxide of Hydrogen had apparently diminished by its catalytic influence the chemical affinity of the 2nd. Equivalent of Oxygen for the protoxide of Manganese; so that the affinity of Sulphuric acid for the protoxid. ~~of Mang.~~ overcoming the affinity of the 2nd Eq of Oxygen for the ~~2nd. Eq of~~ the Protoxide, this 2nd. Eq of oxygen was liberated & the Sulphuric acid combined with the remaining protoxide. In the process which is continually used in the Laboratory to obtain Hydrogen gas, Zinc & water are acted upon by Sulphuric acid & Hydrogen escapes from the decomposed water, a sulphate of protoxide of Zinc ~~&~~ remaining after the evolution of the gas. In this case we may suppose that the tendency of Zinc to become oxidized at the expense of the water had been increased by the presence of Sulphuric acid. But in this case the

Sulphuric acid has combined with water, or at all events has abstracted from the water a certain quantity of Oxygen & Hydrogen, the former being in the nascent state may have been yielded by the sulphuric acid to the Zinc or may have been taken up by the Zinc to enable it to combine with the Sulphuric acid, the Hydrogen was therefore Evolved. - When carbonate of silver is heated with several organic acids as Peruvic acid the oxygen of part of the oxide of silver escapes with the carbonic acid & metallic Silver remains in the state of a black powder. In this case the Peruvic acid appears to be the agent of this Evolution of Carbonic acid & of Oxygen.

No doubt it had a chemical affinity for the oxide of silver, which coming into play, separated it from the carbonic acid which was evolved, but it may be supposed that the peruvic acid in presence of oxide of silver, lost its attributes as an acid, became endowed with a catalytic ~~force~~ property causing the Evolution of the oxygen from the oxide without combining with it.

The reverse, or a base modifying an acid without combining with it when in its 1st state may also occur. Thus Parabanic acid when in presence of any base except oxide of silver does not combine with it, but generates an oxalurate of this base which is a new salt, the acid of which is by no means analogous to the former.

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To be converted into Oxaluric acid, parabanic acid only requires 3 Eq of water; so that the base induces through a catalytic action the parabanic acid to unite with this 3 Eq of water.

Speaking of Catalysis, Mulder says: "This term ought further to be used, with reference to the change of alcohol into Ether by means of Acid. Hydrate of sulphuric Acid, "the common oil of vitriol of the shops", into which alcohol is dropped at an elevated temperature is not diluted, but the water produced by a mixture of oxide of Ethyle & of water distils off, sulphuric acid therefore catalyses at that temperature the Elements of alcohol into oxide of Ethyle & water, without itself combining with Ether." See Catalytic effect of

Thenard & Dulong have detailed a great many Experiments on the subject & have demonstrated that it belongs even to glass when pulverised, but only at a somewhat elevated temperature (@ 572° Far) & to gold & silver at a lower temperature. It had previously been discovered by Sir H. Davy, that Platinum if placed in the vapour either of alcohol or Ether began to glow & to cause combination between the vapours & the Oxygen of the air.

It was afterwards discovered, that even if platinum was moistened with Alcohol, acetic acid was produced from the Alcohol whilst the platinum was glowing. Thus in this case the platinum, merely by its presence had induced a chemical action between the Hydrogen & the Oxygen without taking the slightest part in the chemical reaction, causing the deposition of an abundant dew on the platinum. This is again a strong evidence in favour of the catalytic action of Platinum

Catalysing Effects of Heat.

Heat, under certain circumstances is said to be endowed with a curious Catalytic Property. Thus: if Cyanate of Ammonia be heated, it will be converted into urea a substance quite different from the former, but containing the same number of Component Elements although as it is supposed, arranged in a different order:- it should therefore appear that heat has the power of destroying the Equilibrium existing between the Elements when constituting Cyanate of Ammonia, so that by their natural affinities for each other, they combine under a second form.

Heat acts on Cyammelide, just as it does on cyanate of ammonia, in the latter case, Urea is obtained, in the former Cyanic acid. Admitting the probable formula of Cyammelide to be $C_2O_2 + NH$, it is analogous to that of Cyanic acid, its elements being arranged in a different order (Cyanic acid = CyO, HO or $C_2NO + HO$) As for the curious conversion of Cyanic acid into Cyammelide merely by leaving it undisturbed, it appears to be owing to the potash, that previously combined with the Cyanic acid, this potash must have had some Catalytic property of maintaining a certain equilibrium between the Elements of the Cyanic acid, but when some of that potash had been removed this Equilibrium being destroyed, just as when the key stone of an arch has been removed, new affinities come into play, and therefore a new compound is formed.

Heat is also considered as ~~t~~ possessing the peculiar properties of acting by contact merely, converting urea into cyanuric acid. According to the Composition of Urea, observes Professor Gregory, it ought to yield cyanic acid when deprived of its ammonia but at that temperature, 3 Eq of cyanic acid, $3 Cy O, HO$. combine to form 1 Eq cyanuric acid, $Cy_3 O_3 . 3 HO$.

The action of heat on Cyanuric acid is exactly similar to that in the preceding case, where it causes Cyanuric acid to split into three Eq of cyanic acid & to become from $Cy_3 O_3, 3 HO : - 3 Cy O . HO$.

Many examples of Catalytic action could be brought forward, but the instances already adduced will be sufficient to explain what is meant by such an action though its nature ~~has~~ is as yet, quite obscure; without a clear notion of the action itself it will be impossible to understand that theory which of late had been considered as satisfactory explanations of the Phenomenon of Fermentation

Besides that curious phenomenon of Catalysis the nature of which we have endeavoured to explain; there appears to exist a peculiar state in which a substance is endowed with certain properties which are merely transeant and disappear as soon as it has emerged from that state .. This condition has assumed the name of Nascent State; thus a substance at the moment that it is evolved from the decomposition of another, is in the nascent state and appears to possess in that case a certain number of properties which however disappear as soon as it has combined with another. —

For inst: the combination of Hydrogen with Oxygen gas on spongy platinum has been attributed by some to Catalysis, by other to the nascent state of the Oxygen, or in other terms: the Platinum decomposing the atmosphere at the instant the jet of Hydrogen is brought in contact with it, this Oxygen possesses the curious property of combining directly with the Hydrogen .. (see P 118 The action of Sulphuric acid etc) friction, [illegible] another [illegible] quantity of free vitreous electricity combines with the resinous electricity of the Condenser. Could we not compare this phenomenon to what has taken place in the decomposition of atmospheric air by a lighted jet of Hydrogen. The application of the light is the friction of the glass against the cushions; the light induces a change in the atmosphere, just as friction modifies the electrical properties of the glass; the vitreous electricity of the glass being in the nascent state has the property of decomposing the neutral electricity of the condenser & of combining with its vitreous electricity just as the oxygen of the air brought in the nascent state by the flame applied has the power of developing in the Hydrogen, that tendency which causes its combination with it.

The action of Sulphuric Acid upon Starch has already been noticed, as depending on that peculiar nascent state in which the oxygen & Hydrogen are brought by the action of sulphuric acid which enables these elements to combine with the starch. In short, a great many of these phenomena which have been hitherto unexplained may also be accounted for by the theory of the nascent state & some authors have made use of it, for the purpose of explaining the phenomenon of fermentation.

In 1602 Angelus Sala, defined fermentation as a spontaneous motion of the elementary particles, which have a tendency to unite in a different way, so as to produce a new Compound. Now this is more a theory than a definition, for he endeavours to convey such a notion ~~definition~~ as may explain the phenomenon.

It is curious that this first theory is more in accordance with those which are now advanced than any other, but as to the nature of this "spontaneous motion", the circumstances which accompany it, the actions of a ferment, these various topics were necessarily overlooked by him at such an early period in the history of science.

At a much later period, Thenard brought forward his standard work on Chemistry in which he devoted considerable attention to the subject of fermentation.

Thenard suggests that yeast deprives sugar of part of its oxygen, thus deranging the equilibrium of its component elements; that the oxygen of the sugar combines with the carbon of the yeast, giving rise to carbonic acid; the Hydrogen & Nitrogen of the yeast combining with the remaining constituents of the sugar, producing alcohol.

This theory at first sight appears quite plausible, Thenard omits however the influence of the atmosphere, further he believes that the nitrogen of the ferment combines with the various product & it is now ascertained that there is no nitrogen in alcohol.

According to his view, alcohol should be composed merely of nitrogen & Hydrogen which is Erroneous.

Seguin supposes that water is decomposed, its oxygen uniting with the Carbon of the yeast, generating carbonic acid, and its Hydrogen combining with the sugar forming alcohol; but he overlooks two most important circumstances; 1st that the presence of the atmosphere is required, and secondly that as the Alcohol does not contain more hydrogen than there Existed previously in the sugar, it is impossible that the hydrogen of the decomposed water should have combined with the sugar.

Fabroni shewed at first that this phenomenon was owing to a peculiar action of vegetable acid on Sugar, but later being obliged to admit the necessity of the presence of a nitrogenised substance or ferment he formed the opinion that the carbon of the ferment combined with the oxygen of the sugar so as to produce carbonic acid, whilst the alcohol resulted from a reaction between the remaining Elements of the sugar. But we are prevented from adopting this theory, for it is believed from analysis that the products of fermentation contain Exactly the same number of Elements as the sugar which underwent the modification. Should Fabroni's theory be correct, the carbonic acid & the alcohol resulting from the fermentation, would not be analogous in the quantity of their component Elements, to the sugar which has been decomposed; unless he has been able to prove that the excess of Carbon existing therefore in the sugar had been taken up by some other substance & that the amount of Carbon yielded by the yeast plus the Carbon remaining in the sugar was exactly equal to the amount of this substance found in the alcohol and Carbonic acid resulting from fermentation.

But the great topic of discussion in regard to the theory of fermen-tation is in connection with the three leading opinions viz those of Leibig, Berzelius & Gay Lussac Schweigger & others.

1st. Leibig's theory which may be called, "motion generated by induction"

2nd. Berzelius's theory: Motion generated by Catalysis

3rd. Gay Lussac's theory. Motion generated by Electricity

4th. Motion from contact with growing plants or infusoriae.

Let us examine these four leading theories of the day respecting fermentation.

Leibig when enquiring into the nature of fermentation says; "these changes evidently differ from the class of common decomposition effected by chemical affinity, they are chemical actions, conversions or decompositions, excited by contact with bodies already in the same condition in which the elements in consequence of the disturbance, arrange themselves anew according to their affinities, or in other words Leibig believes that a ferment produces fermentation

~~#~~ We have therefore to examine in succession

1st The progressive decomposition which the ferment suffers from air & water.

2nd The motion induced in the fermenting substance by the decomposition of the ferment.

3rd The nature of the ~~viz~~ balance of affinities which have been destroyed by the ferment in decomposition.

1st The progressive decomposition &c&c

The ferment being necessarily an azotized vegetable or animal substance it must contain those four elements which constitute their essential character viz Carbon, Hydrogen, Nitrogen & Oxygen; if we enquire into the nature of these elements, it will be easily perceived that the affinity of Nitrogen for the other elements being but weak, the substance itself ~~the~~ will be very prone to decomposition, which will assume the characters of putrefaction. The presence of moisture & air being indispensable for this process the use of these media ~~will~~ in regard to fermentation will be easily understood. But if during fermentation, yeast is putrefying it is curious to observe that none of the substances resulting from this putrefaction, as Carbonic acid & ammonia have ever been found.

2nd The motion induced in the fermenting substance &c &c

This motion is of a mixed character, being first Mechanical and secondly Chemical.

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1st Mechanical motion of Particles.

Leibig in favour of this view has attended to numerous facts which shew that motion alone, exercises considerable influence on chemical forces. Thus certain salts when dissolved in a liquid do not crystallize, if the solution is permitted to cool while at rest, but if it receives the slightest movement, the whole liquid becomes suddenly solid with the evolution of heat. An analogous phenomenon happens with water which may be cooled much under 32°, if kept completely undisturbed, but solidifies in a moment when put in motion. —

Again, a salt of Potash only combines with Tartaric acid when the solution is agitated briskly, shewing that the atoms must possess the power of arranging themselves in a certain order to allow their chemical affinities to come into play.

The particles of sugar or sulphur possess a curious degree of mobility even in the condition of a solid; if melted sulphur be cooled rapidly by the action of cold water & at a certain temperature, it remains transparent & elastic & soft, but after a few hours or days, it becomes again hard & crystalline. When a crystal of arragonite is heated, an interior motion of the Molecules is caused by the expansion, the ~~equilibrium~~ permanence of their arrangement is destroyed & the crystal splinters with much violence & falls into a heap of small crystals of calcareous spar.

All these changes are undoubtedly owing to a disturbance of the state of Equilibrium in consequence of which the particles of the body, put in motion other affinities of their own natural attractions; from which Leibig concludes that it cannot be doubted that a body in the act of formation or decomposition, is capable of imparting the same motion or activity in which its atoms are, to those of certain other bodies; or in other words of enabling other bodies with which it is in contact to enter into combinations or suffer decompositions.

It may be mentioned that Mulders theory of chemical action is much in favour of this view. If as he supposes two or more molecules of different substances have a particular chemical action on each other according to the parts of their surface which comes in contact; it easily understood how mechanical motion, by disturbing the relative position of the particles, create new compounds.

2nd. It is chemical.

To explain this chemical motion of atoms, Leibig first compares the atomic constitution of inorganic substances with that of organic compounds. He observes: "In inorganic substances we cannot produce a different arrangement of the atoms, because they are already disposed in the simplest form in which it is possible for them to combine." On the other hand he states that sugar of grapes contains 12 atoms of Carbon 12 atoms of Hydrogen & 12 atoms of oxygen & we know that they are capable of combining in various ways

From the formula of sugar we may consider it either as a hydrate of Carbon, wood starch, or sugar of milk or further as a compound of Ether with alcohol or of Formic acid with Sachulmine. The Elements to form these compounds are therefore contained in the sugar.

3rd The mica balance of affinity existing between &c &c

From what has just been mentioned it is evident that the affinity existing between the elements of such complex substances is but very weak, these elements appear to be in a state of Equilibrium which is disturbed by the slightest cause thus Liebig says that the Elements of the sugar yield to every attraction & to each in a peculiar manner.

In inorganic compounds, an acid acts upon a particular constituent of the body which it decomposes by virtue of its affinity for that Constituent; but when it acts upon sugar & induces great change in that compound, it does this, not by any superior affinity for a base existing in the sugar but by disturbing the equilibrium in the natural attraction of the Elements of the sugar among themselves.

If the force of attraction between the elements of the sugar is to be estimated from the resistance which they offer to the action of bodies brought in contact with them.

Leibig tells us that we must regard the atom of sugar as belonging to that class of compound atoms which exists only by the vis inertiae of their elements. ~~The elements~~ The elements seem ~~entirely~~ to retain passively the position & condition in which they had been placed for we do not observe that they resist a change of these conditions by their own mutual attraction. We may conclude that this interesting theory is well calculated to explain the changes occurring in fermentation, but we are unfortunately so imperfectly acquainted with these phenomena, that there is still sufficient ground for advancing new opinions. A short sketch of the other theories will be required in order to give a somewhat complete statement of the various views which have been taken, in reference to that question. Berzelius's theory ~~in particular~~ has attracted in particular the attention of many chemists, we shall endeavour to give an account of it.

Electrical Theory

Some have asserted that fermentation is owing to an electrical phenomenon, Gay Lussac discovered that if the two poles of a strong galvanic battery were brought in contact with some juice of grapes expressed in vacuo, the juice soon began to ferment & Cohn had induced by analogous means the fermentation of a solution of sugar, one half not having been acted upon by the pile but in every other respect, placed in similar circumstances did not ferment even after a period of 2 months.

Colin considers a ferment as a substance, which by its presence causes a rupture of equilibrium; but, as he observes since the amount of yeast generally employed is but very small, it is impossible to form a clear notion of the action, unless it be considered as resulting from a power, perhaps of an electrical nature which is transmitted by causing each molecule of the fermenting substance to assume a peculiar state. He adds: I consider these views as strengthened by 2 curious observations from Gay Lussac.

1st. That fermentation ~~wh~~ never begins, when air or ~~oxy~~ oxygen gas have been excluded from the fluid and

2d. That a galvanic current will induce this action in those circumstances. Thus, if a single single bubble of air suffices to begin the process I conclude that the chemical action of this air merely generates fermentation by its producing an expansion of the same nature, for I do not conceive the oxidation of the ferment or of its elements should not induce electricity, when on the other hand it is a necessary result from the action of the galvanic battery. Moreover Gay Lussac had observed, "It is impossible to understand why when a ferment of sugar are carefully mixed together, their mutual action should not be more rapid; it would appear to be partly owing to the galvanic process & to be somewhat analogous to the mutual precipitation of metals.

In some cases adds Colin, when the mere action of the atmosphere is not sufficient to induce fermentation, the voltaic battery becomes a necessary agent; this is apparently a powerful proof in support of ~~our~~ my opinion regarding the nature of the Causes which generate the phenomena. I mixed some yeast of beer, which had undergone a previous preparation with a proportion of sugar & water which were most favourable to fermentation & exposed this fluid to the solar rays; its temperature to 18, 35 & even 40°C, nevertheless after 12 days no symptoms of fermentation could be observed & at the end of two months the liquid had preserved its sweet taste it had been slightly acescent & a residue of mould had precipitated, but this was no sign of its being alcoholic or ethereal, whilst on the other hand a second part of that mixture, much similar in quantity & in other respects, placed in analogous circumstances to the former, began to ferment with violence after it had been submitted for a few hours to the action of the galvanic battery, this action gradually increased & when after a fortnight the fluid was examined its alteration was complete; the whole of the sugar had disappeared, and in its place, had been produced alcohol quite devoid of acidity.

From these experiments Colin concludes that Electricity plays a great part in fermentation by communicating renewed energy to yeast which has lost its power, however it is most likely that this yeast requires renewed action of the atmosphere for its fermentable properties to be developed & that the galvanic battery by decomposing water afforded to the yeast that very supply of oxygen which in other circumstances it would have derived from the atmosphere, thus the yeast was capable of generating in the sugar a fermenting process. Schweigger has endeavoured to show that ferment constitutes in sugar & water, a number of small electric couples, suspended in every part of the fluid, But says Berzelius, we cannot admit this theory, because in the above case there are but two elements coupled together; the ferment & the solution of sugar & one of these elements, completely & uniformly envelopes the other, one as a liquid, thus preventing the generation of Electricity by ~~[illegible]~~ induction which depends upon an unequal action effecting the opposite sides of a solid body. It is probable however that Electricity plays the principal part in the case of Lactic Fermentation, induced by Meteorological Phenomena. It is a fact well authenticated that new milk, cream &c becomes sour from the production of Lactic acid during a thunder storm, now is this owing to a diminution of atmospheric pressure, to the increase of temperature, to the moisture of the Atmosphere or to its Electrical state. This question requires renewed investigation to be satisfactorily answered, it is however striking that this lactic fermentation should take place spontaneously during a thunder storm when the atmosphere is in a peculiar Electrical state, generally accompanied by an increase of temperature.

In this case, Electricity may act, directly or indirectly. for it cannot be said to have decomposed the water of the milk causing an evolution of Oxygen gas, for we cannot conceive two different Electricities coming in such close vicinity as to act simultaneously upon a surface of milk without neutralizing each other at the surface of the fluid without acting upon it.

2nd. Indirectly. We must therefore look for another Explanation of this curious phenomenon.

Professor Schönbein has discovered lately that a development of Electricity in the atmosphere was always accompanied with the presence of a substance which he calls Ozone & which he conceives to be generated by this phenomena. this Ozone or tritoxide of Hydrogen if absorbable by the milk may perhaps act upon it as a ferment & thus Explain this curious ~~phenomenon~~ property of thunder storms. In this case however it may also happen that the Ozone being absorbed should be immediately decomposed evolving 2 Eq Oxygen & thus every particle of the Caseine coming in contact with Oxygen in the nascent state, may be caused to decompose & to generate fermentation in the milk. ~~Again the~~ Ozone may also act as an acid, coagulating the Caseine & thus bringing it more directly under the influence of the atmosphere.–

Again if we admit nitric acid to be generated by storms it may be that this acid coagulates the particles of Caseine on the surface of the milk which begin immediately to decompose at the expense of the atmosphere & thus becoming a ferment. In favour of this theory, the milk put aside in wide & shallow basons to collect the cream seems peculiarly liable to be attacked by a thunder storm. In this case a wide surface being exposed to this supposed influence of nitric acid, the milk would be more readily acted upon than if it were contained in a deep & narrow vessel. The elevation of temperature & diminution of atmospheric pressure no doubt accelerates the action. Lactic fermentation however is possibly induced by the evolution of the air contained in the milk owing to a diminished atmospheric pressure accompanied by excessive heat, so that every particle of caseine coming in contact with a bubble of atmospheric gas is thus caused to commence decomposition.

We ~~was~~ induced to advance several hypotheses on this interesting subject, without being prepared to admit one in preference to another, only ~~them inclined to~~ believe ~~that~~ we are inclined to believe that a curious series of investigations could be instituted which would satisfactorily shew whether ~~[struck]~~ anyone be trustworthy.

Fermentation attributed to the Effect of animalcules &c &c

Let us now consider the third view which has been advanced to Explain the phenomenon of Fermentation, which is admirably described in Leibig's Chemistry of vegetable physiology. He says: the microscopic Examination of animal or vegetable matter in the act of fermentation or putrefaction has lately given rise to the Opinion that these actions themselves & the changes suffered by the body subjected to them are produced in consequence of the development of fungi, or of microscopic animals, the germs or Eggs of which are supposed to be diffused every where in a manner inappreciable to our senses & to be developed when they meet in a medium fitted to afford them nourishment. The philosophers who have propounded this theory assert that the decomposition of sugar into alcohol & carbonic acid is Effected by contact of the particles of the sugar with the growing plants which they view as the yeast or ferment, without studying more closely the first causes of the decomposition of the sugar. According to Leibig as we know from the Experience of Gay Lussac that fermentation cannot take place without the interference of oxygen gas, it can scarcely be supposed that the germs of fungi Existed in Chlorate of Potash or Black Oxide of Manganese, but of which the gas was

obtained, & hence it is difficult to ascribe to a growing vegetation the cause of the decomposition. Gay Lussac moreover caused juice of grape to ferment by means of the galvanic battery, under circumstances therefore which quite excluded the introduction of any foreign body.
Hence this view, that fermentation of sugar is effected by contact with growing plants, & presupposes that living beings may be formed without germs or buds, a circumstance in direct contradiction to all that is known regarding the growth of plants. However we may observe that the germs or ovules of vegetables or of such animalculi might be introduced by the yeast in the fluid, & that they required the presence of oxygen to be developed. In favour of this view we can remember that under the microscope according to Caguard Latour a ferment is seen to be composed of granules or corpuscules, their margins being lined with appendages somewhat similar to true germs annexed to the mother cell, whenever the liquid has begun to ferment the sides of these small disks increase & they become free & give rise in their turn to true germs.
But even in this case if the existence of these germs be admitted we have yet to shew how they can account for the phenomena of fermentation. Several theories have been advanced in explanation, but they are so improbable that we need not advert to them. Liebig however proceeds to shew that we must admit that they accelerate the phenomenon in a singular degree. His words are: There have

been many wonderful & incomprehensible observations on the behaviour & functions of certain microscopic animals.

From these observations there seems to follow conclusions regarding the nutrition & growth of the creatures quite at variance with all that we know on the process of nutrition of the higher classes of animals. In a treatise on the composition of the salt springs of Hesse Cassel, Wöhler mentions a singular phenomenon namely that the slimy mass which deposits in the tubes ~~of the~~ to receive the brine percolating thro' the ~~pores~~ walls of the graduating house contains a gas which is found to be pure oxygen.

The fresh brine obtained directly from the draw well is quite clear & contains 5% of salts with gypsum & sulphuretted hydrogen in such quantity ~~that~~ it might be used as sulphureous waters. During the summer months a shining transparent mass forms in this brine, covering the bottom of the vessels containing it to the depth of one or two inches. This matter is every where filled with bubbles of gas of considerable size, which rise to the surface, when the membrane including them is torn with a stick the quantity of gas bubbles is so great that it would be easy to fill hundreds of bottles with them in a short time. They are so rich in oxygen that a glowing match introduced into the collected gas, bursts into flame & continues to burn with brilliancy. On being analysed

it is found to consist of 51% of oxygen & 49 of Nitrogen, but there can be but little doubt that the gas originally consisted of pure oxygen which became mixed with the nitrogen of the air by virtue of diffusion just as it does when confined in an animal membrane.
In fact it is found that when the water in the tubes is very low, the bubbles existing in the deposit appear to be pure air owing to the celerity with which the diffusion has taken place. Wöhler has submitted to examination the slimy membraneous deposit & has shewn that it consists entirely of living and of moving infusoria principally of the species of Galionella & Navicula; the whole deposit possesses a slightly greenish colour and is intersected with very fine fibres of conferva, this on being heated gives distinct indications of ammonia shewing that it contains nitrogen. It yields also a mass resembling paper which after incineration being treated with muriatic acid leaves behind siliceous skeletons which preserve the shape of the animal so completely that it appears as if the original deposite itself were submitted to examination.
Wöhler inquires how it is that this liquid with the aid of the solar light should become such an abundant source of oxygen gas :—
Sir B. Thompson (Count Rumford) discovered

about 50 years ago that silk, cotton, Eider down, sheep's wool, and other organic substances evolved oxygen gas when freed from air by washing, and exposed to the sun's light in a glass globe perfectly filled with water. After two or three days the water assumed a greenish hue and from that moment the evolution of gas commenced. 100 grains of cotton immersed in 296. cubic. inches of spring water gave out during the first four days $2\frac{3}{4}$ C. inches of gas containing hardly any oxygen. It was not till the 6th day when the sun was very powerful that the water became suddenly green & gave out during the next 6 days $44 \frac{1}{2}$ C. inches of oxygen nearly pure. On examining the water under the microscope, it was found to contain a multitude of very minute, nearly spherical animalculi insomuch that the green colour seemed to be caused by them. These phenomena adds Thompson may be explained if we admit that the gas thus produced in the water was derived from the green matter and that the leaves, silk, cotton &c only facilitated its disengagement by furnishing a surface adapted to the collection and the escape of the gas bubles.—

These phenomena, Observes Liebig, may also be explained by an assumption favourable to the hypothesis of Priestly, namely that the green matter

consists of plants which adhering to the surface of the bodies placed in the water, there vegetate & in consequence give rise to the gas, I would willingly (adds Leibig) adopt this opinion were it not that a most careful & a most attentive examination of the green water by means of an excellent microscope at the period when the oxygen was most abundantly disengaged, convinced me that at this period, nothing to which the name of vegetable can be given is present. The colouring matter ~~of~~ in the water is of an animal nature & is nothing else but an accumulation of little moving animals without venturing on the mode of nutrition of these animals it is quite certain that the water containing living infusoria becomes a source of oxygen gas when exposed to the action of light.
It is also quite certain that as soon as these animals can be detected in the water, the latter ceases to act injuriously to plants or animals for it is impossible to assume that pure oxygen gas can be evolved from water containing any putrefying or decaying matters, for these possess the property of combining with oxygen, indeed it is obvious that if we add to this water any animal or vegetable in a state of decay, this being in contact with ~~water~~ oxygen, it will resolve itself into the ultimate products of oxidation in much shorter time than infusoria were not present. These animalculi therefore cannot

be viewed as a cause of putrifaction or of the generation of products injurious to animal & vegetable life, but they make their appearance in order to accelerate the conversion of putrefying organic matter into its ultimate products. As for Thompsons Experiments where cotton &c Exposed under water to the action of the Sun, was made to give off oxygen gas, certainly the fact is Extremely curious. In this case may be considered 1st the generation of animalculi under the influence of the suns rays & 2nd the evolution of oxygen gas from these animals. As to the generation of animalculi it may 1st be Enquired is this a fact; for unless a decidedly animal structure has been noticed, the Eye of the observer may have been deceived for particles moving in a fluid from some unknown cause and not for that reason Endowed with life. 2nd Evolution of oxygen gas. We are acquainted with many chemical properties of the suns rays. Thus we know that some substances combine with others when Exposed to the suns rays. Chlorine may combine in this case with Hydrogen = Hydrochloric acid or with CO to form Chloro-Carbonic acid &c. The action of the Sun might induce some Chemical change between the water & the cotton setting free the oxygen of the former. Or perhaps it might have produced some change similar to the phenomenon of respiration of plants the performance of which required the presence of the Sun

Again a strong sun may perhaps cause a revival of the functions they were capable of fulfilling when they constituted part of a living plant. In short I believe it is still very difficult to account for the singular evolution of oxygen gas, but should fermentation take place in a fluid where this gas is evolved, there is no doubt but that it would highly contribute to hasten the phenomenon.

We have now to consider the 3rd. Last theory which has been advanced by Berzelius to explain the phenomenon of fermentation.

We have deemed it necessary to lay some stress on catalytic action & the properties of substances in the nascent state so as to render intelligible the following speculation of Berzelius which is highly deserving of notice.

Berzelius observes in his traité de Chemie Vol VI P. 403 we are but imperfectly acquainted with the phenomena which accompany the various fermentation it may possibly be owing to a new series of forces the action of which is not yet well understood & analogous to those which accompany the action of spongy platinum upon Hydrogen gas or to the decomposing power of the noble metals or of their oxides when acting on Peroxide of Hydrogen. Perhaps we may be allowed to enter into a few details respecting this hypothesis

Taking as a type, the alcoholic fermentation, the yeast from its complex nature is prone to undergo decomposition its Carbon will have a powerful chemical affinity for the oxygen of the sugar, just as a noble metal has a strong affinity for the oxygen of the Peroxide of Hydrogen, which it decomposes. The affinity of the oxygen of the sugar of the other constituents of that substance is diminished to such an extent that the equilibrium between the elements of the sugar is destroyed the Hydrogen & the Carbon now form a new compound, just as when Cyanate of Potash is converted into Cyamelide when the potash is withdrawn which finding the oxygen of the sugar in the nascent state has the property of combining with it & thus to produce alcohol & carbonic acid; To compare this process with the combination of Hydrogen & Oxygen on spongy platinum, the carbon of yeast is the platinum, sugar is the atmosphere, the oxygen of sugar is the oxygen of the air which is brought in the nascent state by the action of the Platinum just as the oxygen of the sugar is brought into that state by the Carbon of the yeast. In this theory the carbon of the ~~sugar~~ yeast must be supposed to be endowed with a catalytic action which it exerts upon the sugar.

When entering on this part of the subject & these conditions have been stated necessary for any theory of fermentation to be admissible. We believe the latter is fitted to answer these conditions. 1st. It is in perfect accordance with the various conditions required for fermentation

to take place, as the ferment is necessary in order to act upon the oxygen of the fermenting substance
Air is indispensable to begin the putrefaction of the yeast and thus to bring its carbon in such a state as may enable it to acquire catalytic properties.
Heat & moisture are necessary conditions to promote the putrefaction of the yeast. The sugar moreover must be in solution to come more rapidly & completely under the action of the ferment. 2nd The last theory explains though differently yet as plausibly as that of Liebig the changes which accompany fermentation.
3rd The latter theory agrees remarkably well with the fact we have stated, that the amount of alcohol & carbonic acid produced contained the same quantity of carbon hydrogen & oxygen as the sugar which has undergone the change since nothing has been added or withdrawn from the sugar
To conclude, of the various theories which have been advanced the facts of which we are ~~in~~ at present in possession do not warrant us to say whether the theory of Liebig or of Berzelius be true, it is to be hoped that ere long a new series of investigations will settle this important & interesting question.
Let us ... observe that the same theory of fermentation can hardly be applicable to every variety of this phenomenon though the principle on which it acts is the same.

(End.)

Wm. Marcet