

**An inventory of semiotic agents present in Louis Pasteur's famous  
Memoir on Lactic Acid with special considerations to Simon  
Schaffer's criticisms leveled against the 'hylozoism' of Latour**

This document contains:

- 1° the complete translation of one paper by Pasteur (see for reference Conant's Harvard case study on spontaneous generation)
- 2° the same text underlined and segmented by myself;
- 3° a rather complete semiotic inventory of the same text;
- 4° a tentative draft of a paper using this semiotic treatment to answer science studies question (partially published in (51) 1993: « Pasteur on lactic acid yeast- a partial semiotic analysis" in **Configurations** Vol.1 n°1, pp.127-142)

This is an unpublished draft of preliminary ground work on the question of agency done in 1992 in San Diego.

## Mémoire sur la fermentation appelée lactique

(Conant's translation revised and completed by BL)

### I- Foreword

1- I feel I must point out a few words how it came about that I undertook my study of fermentations. Having until now directed all my efforts toward attempting to discover the relations that exist among the chemical, optical and crystallographic properties of certain substances, with the objective of shedding light on their molecular constitution, it may seem surprising that I should take up subject dealing with physiologic chemistry apparently quite remote from my first labors: nevertheless, it is very directly related to them.

2- In one of my recent communications to the Academy, I showed, contrary to what had been thought until then, that amyl alcohol was composed of two distinct, isomeric alcohols, one rotating the plane of polarized light to the left, the other devoid of any action. The properties of these alcohols are extremely similar. But the fact that they have presented the first known exception to the "law of hemihedral correlation" gives them a special value in connection with the studies that I have undertaken. I then resolved to make a thorough study of the two amyl alcohols to determine, if possible, the causes of their simultaneous production and their true origin about which certain preconceived ideas led me to dissent from the accepted opinion. The molecular constitution of sugars seems to me to be very different from that of amyl alcohol. If this alcohol, when active, originated from sugar, as all chemists agree, its optical activity would derive from that of the sugar. I am loath to believe this, considering the present stage of our knowledge, for every time that one tries to find the optical activity of a substance in its derivatives, it promptly disappears. The fundamental molecular group must remain in some measure intact in the derivative if the latter is to continue to be optically active., a result that can be foreseen from my investigations, since the property of optical activity is entirely due to an unsymmetric arrangement of elementary atoms. But I find that the molecular group of amyl alcohol is too distant from that of sugar to retain the unsymmetric arrangement of atoms, in case it derives from it. I repeat these were preconceived ideas. However, they were sufficient to persuade me (*me déterminer*) to study what the influence of a ferment might be in the production of the two amyl alcohols. For it is always observed that these alcohols originate in the process of fermentation, and this fact was one more invitation to press on (*persévérer*) toward a solution of these problems. For indeed, I must confess that my researches have long been dominated by the thought that the constitution of compounds considered from the point of view of molecular symmetry or lack of symmetry (all of other things being equal) plays a considerable role in the most intimate laws of organization of living organisms and intervenes in their most hidden physiologic characteristics.

3- Such was the origin and the motive for the new experiments on fermentations. But as often happens in similar circumstances, my work grew little by little and deviated from its original direction in such a way that the results that I am publishing today seem alien to my previous studies. I subsequently hope to connect the phenomena of fermentation with the molecular dissymmetry characteristic of substance of organic origin.

### II. History

4-Lactic acid was discovered by Sheele in 1780 in soured whey. His procedure for removing it from the whey is still today the best one can follow<sup>1</sup>. The inaccurate work of Bouillon-

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<sup>1</sup> First he reduced the whey to an eighth of its volume by evaporation. He filtered it and saturated it with lime to precipitate the phosphate of lime. The liquid was then filtered and diluted with three times its weight of water; into this he poured oxalic acid drop by drop to precipitate all the lime. He evaporated the liquid to the consistency of

Lagrange and several others confused the study of its properties; this resulted in 1813 in Braconnot's describing as if new, under the bizarre name of aci of Nancy or "nanceique acid", a product that was nothing else than Sheele's lactic acid. Nevertheless, Braconnot's work is one of the most thorough of the numerous memoirs that have dealt with this acid. He found the acid in rice that had fermented under water; in beet juice that, having undergone viscous fermentation and alcoholic fermentation, becomes sour and yields lactic acid and mannite; in some sour water made of baker's yeast; finally in sour's milk and in Scheele's lactic acid.<sup>2</sup> The composition of lactic acid was established by Messrs. Pelouze and J. Gay Lussac in 1853<sup>3</sup> Later in 1841 Messrs Fremy and Boutron published a work meriting special mention in the history of this substance, for in it they described the method of prolonging the action of nitrogenous organic material on sugars, in such a way as to transform these sugars more completely into lactic acid. They noticed that the action of the casein was stopped by the lactic acid itself, and by saturating the liquid from time to time with bicarbonate of soda they were able to transform all the sugar in the milk. Messrs Pelouze and Geliz did better; they added chalk to the sweetened water and to the ferment. The chalk constantly maintains the neutrality without any need for supervision on the part of the experimenter. Then, by taking up again Braconnot's experiments and imitating those of Mr Colin on alcoholic fermentation, it was possible to make the sugar undergo lactic fermentation with the help of any of the nitrogenous plastic materials. Indeed the conditions for the preparation and the production of lactic acid are well known to the chemists. Today everyone knows that by adding chalk to sweetened water plus a nitrogenous substance such as casein, gluten, animal membranes, fibrine, albumin, etc. the sugar is transformed (*se transforme*) into lactic acid. But the explanation of the phenomena remains very obscure. We entirely ignore the mode of action of the nitrogenous plastic material. Its weight does not change perceptibly. It does not become putrid. However, it becomes altered and is continually in an evident state of decomposition, although it is difficult to say in what this consists. Until now minute researches have been unable to discover the development of organized beings. Observers who have recognized some of those beings have at the same time established that they were accidental and spoiled the process.

5-The facts then seem very favorable to the ideas of Liebig or to those of Berzelius. In the eyes of the former a ferment is an excessively alterable substance that decomposes itself and thereby excites fermentation in consequence of its alteration by disrupting through communication and by disassembling the molecular group of the fermentable matter. According to Liebig, such is the primary cause of all fermentations and the origin of most contagious diseases. Berzelius believes that the chemical act of fermentation is to be referred to the action of contact. These opinions gain more credit daily. In regard to this one can consult the Memoirs of Messrs Fremy and Boutron on lactic fermentation, the pages dealing with fermentation and ferment in the excellent work that Mr Gerhardt left when he died and Mr Bertholet's very recent memoir on alcoholic fermentation. These works all agree in rejecting the idea of some sort of influence from organization and life as a cause of the phenomena that we are considering. I have been led to an entirely different point of view.

6- In the first part of this work, I plan to show that just as an alcoholic ferment exists, namely, brewer's yeast, which is found wherever a sugar breaks down into alcohol and carbonic acid, so too there is a special ferment, a lactic yeast, always present when sugar becomes lactic acid, and that if any nitrogenous plastic material can transform sugar into this acid it is because it is a food suitable to the development of this ferment.

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honey. The thickened acid was redissolved in rectified alcohol, which eliminated the milk sugar and many other materials. The alcohol was removed by distillation.

<sup>2</sup> ref by Pasteur

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### **iii new yeast -its preparation- its properties-analogies and differences with brewer's yeast**

7- If one examines carefully an ordinary lactic fermentation, there are cases where one can find, on top of the deposit of the chalk and of nitrogenous material, spots of a grey substance which sometimes form a layer (*formant quelquefois zone*) on the surface of the deposit. At other times, this substance is found adhering to the upper sides of the vessel, where it has been carried by the movement of the gases. When examined under the microscope, when one is not forewarned (*prévenu*), it is hardly possible to distinguish it from casein, disaggregated gluten, etc.; in such a way that nothing indicates that it is a special (*special* separate in Conant) material, or that it was produced during the fermentation. Its apparent weight always remain very little as compared to that of the nitrogenous material originally necessary for the carrying out of the process. Finally, very often it is so mixed with the mass of casein and chalk that there would be no reason to suspect its existence. It is it nevertheless that plays the principal role. I am going to show, first of all, how to isolate it and to prepare it in a pure state.

8- I extract the soluble part from brewer's yeast, by treating the yeast for some time with fifteen times its weight of water at the temperature of boiling water. The liquid, a complex solution of albuminous and mineral material, is carefully filtered <sup>4</sup>. About fifty to one hundred grams of sugar are then dissolved in each liter, some chalk is added, and a trace of the gray material I have just mentioned from a good, ordinary lactic fermentation is sprinkled in; then one raises the temperature to 30 or 35 degrees centigrade. It is also good to introduce a current of carbonic acid in order to expel the air from the flask, which is fitted with a bent exit tube immersed under water. On the very next day a lively and regular fermentation is manifest. The liquid, originally very limpid, becomes turbid; little by little the chalk disappears, while at the same time a deposit is formed that grows continuously and progressively with the solution of the chalk. The gas that is evolved is pure carbonic acid, or a mixture in variable proportions of carbonic acid and hydrogen. After the chalk has disappeared, if the liquid is evaporated, an abundant crystallization of lactate of lime forms overnight, and the mother liquor contains variable quantities of the butyrate of this base. If the proportions of chalk and sugar are correct, the lactate crystallizes in a voluminous mass right in the liquid during the course of the operation. Sometimes the liquid becomes very viscous. In a word, we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists.

9- In this experiment the yeast extract can be replaced by an extract of any nitrogenous plastic substance, fresh or decomposed, as the case may be. This limpid liquid, containign a nitrogenous substance in solution, is nothing but food, and in this respect its origin is of little importance provided it is of such a nature as to facilitate the development of the organized body (*corps organisé*) that produces itself and is gradually deposited.

10- Let us now consider what are the characteristics of this substance, the production of which is correlated with phenomena pertaining to the denomination of lactic fermentation. When it solidifies (*prise en masse*) it looks exactly like ordinary pressed or drained yeast. It is slightly viscous, and gray in color. Under the microscope, it appears to be formed of little globules or very short segmented filaments, isolated or in clusters, which form irregular flakes ressembling those of certain amorphous precipitates. [forgotten by Conant: The globules, much smaller than those of brewer's yeast, are swiftly agitated, when isolated, of the brownian

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<sup>4</sup> If it does not come through clear, it can easily be made limpid by bringing it to a boil with a little chalk or by adding a very little lime water or sucrate of lime, which produces an abundant precipitate. This precaution is almost always necessary when the yeast water has been prepared from yeast that has been in contact with much water for several days. Fresh yeast or that which is submitted to only one of tro washings by cold decantation gives a yeast water that is very limpid with filtration.

movement, that is, of the movement that matter always undergoes when suspended in a liquid at a sufficient state of division<sup>5</sup>. Washed by water through decantation, then diluted in pure sugared water, it makes it acid immediately, progressively (sic the French is unclear), but very slowly, because the acidity hinders its action on sugar. If one makes the chalk intervene, which maintains the neutrality of the milieu, the transformation of sugar is sensibly accelerated, and in less than an hour the production of gas is manifest and the liquor is rich in lactate and butyrate of lime in various quantities. When, on the other hand, there is some albuminoid matter adapted to the feeding of the substance, it develops itself and one crop (*recueille*) amounts that have no other limits than the weight of the sugar or that of the albuminoid matter.] It can be collected and transported for great distances without losing its energy. Its activity is weakened only when it is dried or boiled in water. Lastly, very little of this yeast is necessary to transform considerable amount of sugar. These fermentations should preferably be carried on so that the material is protected from the air, so that they will not be hindered by vegetation of foreign infusoria.

11- Here we find all the general characteristics of brewer's yeast, and these substances probably have organic structures that, in a natural classification, place them in neighboring species or in two connected families.

12- All the chemists will be surprised at the rapidity and regularity of lactic fermentation under the conditions that I have specified, that is, when the lactic ferment develops alone; it is often more rapid than the alcoholic fermentation of the same amount of material. Lactic fermentation as it is ordinary carried out takes much longer. This can easily be understood. The gluten, the casein, the fibrin, the membranes, the tissues that are used contain an enormous amount of useless matter. More often than not these become a nutrient for the lactic ferment only after putrefaction -alteration by contact with plant or animalcules- that has rendered the elements soluble and assimilable.

13- There is another characteristic that permits one to compare this new ferment with brewer's yeast: if brewer's yeast instead of the lactic ferment is sown in limpid, sugared, albuminous liquid, brewer's yeast will develop, and with it, alcoholic fermentation, even though the other conditions of the operation remain unchanged. One should not conclude from this that the chemical composition of the two yeasts is identical any more than that the chemical composition of two plants is the same because they grew in the same soil.

14- Then there is the final analogy which I must not omit, namely, that it is not necessary to have at hand some lactic ferment to prepare more: it originates spontaneously, with as much facility as brewer's yeast, whenever conditions are favorable.<sup>6</sup>

15- If one dissolve some sugar in limpid yeast water, and adds chalk, fermentation will set in on the following day or the day after, and because the medium is neutral, it will tend to be exclusively a lactic fermentation. Sufficient contact with the air will take place during the mixing unless very particular precautions are taken (which I do not assume) and indeed it will be useless to prevent it. Nevertheless, it is preferable to sow a little lactic ferment in the liquid, for if one does not, there is apt to be a simultaneous development of several fermentations and that of animalcules which are very injurious.

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<sup>5</sup> I do not assign a size to the globules. I think that at such a minuteness of matter, illusions produced by light on the edges of the globules lead to errors which are of the same order of magnitude as the measures themselves. It is nevertheless a point that other persons more skilled than myself in microscopy will resolve with a greater certainty.

<sup>6</sup> I use this word to describe the fact, leaving entirely aside any judgment on the question of sugar. The lactic ferment develops in contact with common air if the conditions with respect to the medium and temperature are favorable. If the experiment is carried out under conditions where the air is excluded or in the presence of air that has been previously heated, the process that takes place is the same as with brewer's yeast or infusoria, and under these conditions one can reproduce the well known experiments of various physiologists who have repeated and made more precise the work of Appert and Gay-Lussac on the influence of air on the phenomena in question.

16- Whenever an albuminous liquid of a suitable nature contains a substance such as sugar, capable of undergoing diverse chemical transformations dependent upon the nature of such and such a ferment, the germs of these ferments all tend to propagate at the same time, and usually they develop simultaneously, unless one of the ferments invades the medium more rapidly than the others. It is precisely this last circumstance that one determines when one use this method of sowing an organism that is already formed and ready to reproduce. If no ferment is sown in a mixture of sugared water, albuminoid matter, and chalk, there generally are several parallel fermentations, with their respective ferments, and animalcules that seem to devour the little globules of these ferments. The addition of a definite pure ferment greatly assist the production of the corresponding fermentation, though without ensuring it in every case. What takes place in fermentations may be compared to what occurs in a plot of land that is not seeded. It soon becomes crowded with various plants and insects that are mutually harmful.

17- One of the essential conditions for good fermentations is the purity of the ferment, its homogeneity, its free development without any hindrance and with the help of a nutrient well adapted to its individual nature. In this respect, it is important to realize that the circumstances of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids play an important part in the predominant growth of such and such a ferment, because the life of each does not adapt itself to the same degree to different states of the environment. If some sugar is dissolved, for example, in very limpid yeast water without adding chalk and without sowing anything, one may be assured that two days hence the fermentation will be alcoholic, the yeast being deposited at the bottom of the vessel. However, in very rare cases, as has been proved to me at various times by numerous experiments, the ferment that develops will be lactic ferment. I repeat, that is an exception if this happens, even though lactic ferment may previously been sown. This is because, under such conditions, the liquid may become acid, and acidity seems to weaken and interfere with lactic ferment more than it does with the alcoholic ferment. There is yet much research to be done in this direction.

18- If on the contrary the medium is made neutral or a little alkaline the lactic ferment will have a great tendency to appear and then increase. The definitive proof of this statement follows. If one adds alkaline magnesia to sugared water and brewer's yeast, alcoholic and lactic fermentation will take place simultaneously with the formation of a crystalline precipitate of magnesium lactate; a microscopic examination of the liquid shows the presence of a considerable quantity of the little globules of the lactic ferment mixed with the globules of brewer's yeast. These globules arise simultaneously from the albuminous liquid furnished by the soluble part of the brewer's yeast, as the alkalinity of the liquid considerably diminishes the activity of the yeast as an alcoholic ferment. A slightly alkaline medium is thus very convenient for the development of the new yeast, but it is also eminently favorable to the infusoria, which, by consuming the new globules or at least removing their source of nourishment often prove to be an insurmountable hindrance to this class of phenomena.

[omitted by Conant 19- The brewer's yeast offer peculiarities of the same nature. (...)

[20- The details in which I have just entered allow us to anticipate all the variations to which fermentations could be subjected, and in particular the lactic fermentation, which requires a milieu the neutrality of which is also well adjusted for other vegetals and infusories. Even if one follows all the precautions I have indicated, it often happens that complications arise and that there is coincidence of various phenomena. We saw that it was the brewer's yeast that was the greatest hindrance. I had then to look for the proper circumstances that could stop its development without interfere notably with that of the lactic yeast. I hope I can succeed through the use of rough (*brut*) onion juice as the albuminous medium. The essential oil (*huile essentielle*) of this juice completely hinders the formation of brewer's yeast; it seems also to be injurious to infusories. I will thus come back, in a special work, on the usefulness of this natural juice.

[21- Even though, through the use of oignon juice it would be impossible to solve the difficulty, that is to exactly trigger constantly and easily lactic fermentation without the complication of ferments and infusories foreign to the phenomena, all the facts that I have gathered lead me to believe that the most efficient mean to reach this result is to try to hamper (*chercher à nuire*) the production of parasitic ferments by means of particular substances. If one sows, for instance, fresh globules of brewer's yeast in the juice of oignon, never those globules will develop. They never trigger alcoholic fermentation. On the other hand, if one boils the oignon juice, which has for effect to separate the sulfur essential oil (*chasser l'huile essentielle sulfurée*), and may be to modify its albuminous principles, the brewer's yeast will develop in the cooled liquid with remarkable efficiency, and the sugar either of the juice or that one may have added, will be changed in alcohol and carbonic acid. Thus, alcoholic fermentation never starts spontaneously in the natural oignon juice, although it is as acid and grape juice, although it always undergoes the lactic fermentation linked or not to various peculiarities upon which I will later call attention.

22- All through this memoir, I have reasoned on the basis of the hypothesis that the new yeast is organized, that it is a living organism, and that its chemical action on sugar corresponds to its development and organization. If someone were to tell me that in these conclusions I am going beyond that which the facts prove, I would answer that it is quite true, in the sense that the stand I am taking is in a framework of ideas (*un ordre d'idées*) that in rigorous terms cannot be irrefutably demonstrated. Here is the way I see it. Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be inclined to assign their primary cause to a type of reaction consistent with the general results of his own research. It is the logical course of the human mind in all controversial questions. And it is, in my opinion, at this point in the development of my knowledge of the subject, that whoever judges impartially the results of this work and that which I shall shortly publish will recognize with me that fermentation appears to be correlative to life and to the organization of globules, and not to their death and putrefaction, no more than fermentation is a phenomenon due to contact in which the transformation of sugar would take place in the presence of the ferment without giving up anything to it or taking anything from it. These latter facts, as we will see shortly, are contradicted by experiments.

23- In a work that will follow shortly, I shall take up the chemical action of the new yeast on sweetened substances.

Convention:

() separates blackboxed or grayboxed background mobilised in the text

[] separates moment of redefinition of the entities composing the narrative

{ } separates experimental procedures in various degree of stylization

underline indicates the enunciation structure (author, narrator, actors, shifting out, time and space)

**bold** highlights important words

***bold italic*** highlights the main circulating non human object and its evolving properties

## Mémoire sur la fermentation appelée lactique

(Conant's translation revised and completed by BL)

### -section 1: the metanarrative: why I did this and what we look for-

#### I- Foreword

1- I feel I must point out a few words how it came about that I undertook my study of fermentations. Having until now directed all my efforts toward attempting to discover the relations that exist among the chemical, optical and crystallographic properties of certain substances, with the objective of shedding light on their molecular constitution, it may seem surprising that I should take up subject dealing with **physiologic chemistry** apparently quite **remote** from my first labors: nevertheless, it is very **directly related** to them.

2- In one of my recent communications to the Academy, I showed, **contrary** to what had been thought until then, that [amyl alcohol was composed of two distincts, isomeric alcohols, one (rotating the plane of polarized light) to the left, the other devoid of any action]. The properties of these alcohols are extremely similar. But the fact that they have presented the first known exception to the ("law of hemihedral correlation") gives them a special value in connection with the studies that I have undertaken. I then resolved to make a thorough study of the two amyl alcohols to determine, if possible, the causes of their simultaneous production and their [true origin] about which **certain preconceived ideas led me** to dissent from the accepted opinion. The molecular constitution of sugars seems to me to be very different from that of amyl alcohol. If this alcohol, [when active, originated from sugar, as all chemists agree, its optical activity would derive from that of the sugar. I am loath to believe this, considering the present stage of our knowledge, for every time that one tries {exp} to find the optical activity of a substance in its derivatives, it promptly disappears. The fundamental molecular group must remain in some measure intact in the derivative if the latter is to continue to be optically active.,] a result that can be foreseen from my investigations, (since the property of optical activity is entirely due to an unsymmetric arrangement of elementary atoms). But I find that [the molecular group of amyl alcohol is too distant from that of sugar to retain the unsymmetric arrangement of atoms, in case it derives from it.] I repeat **these were preconceived ideas**. However, they were sufficient to persuade me (*me déterminer*) to study what [the influence of **a ferment** might be] in the production of the two amyl alcohols. For (it is always observed that these alcohols originate in the process of fermentation), and this fact was one more invitation to press on (*persévérer*) toward a solution of these problems. For indeed, I must confess that my researches have long been dominated by the thought that the constitution of compounds considered from the point of view of [molecular **symmetry** or lack of symmetry (all of other things being equal) **plays a considerable role** in the **most intimate** laws of organization of living organisms and intervenes in their **most hidden** physiologic characteristics].

3- Such was the origin and the motive for the new experiments on fermentations. But as often happens in similar circumstances, my work grew little by little and deviated from the its original direction in such a way that the results that I am publishing today seem alien to my

previous studies. I subsequently hope to connect the phenomena of fermentation with the molecular dissymmetry characteristic of substance of organic origin.

## **-section 2: black and greyboxes: what has been done before to produce lactic acid-**

### II. History (*historique*)

4-Lactic acid was discovered by Sheele in 1780 in soured whey. (His procedure for removing it from the whey is still today the best one can follow<sup>7</sup>).

(Note 1: First he reduced the whey to an eight of its volume by evaporation. He filtered it and saturated it with lime to precipitate the phosphate of lime. The liquid was then filtered and diluted with three times its weight of water; into this he poured oxalic acid drop by drop to precipitate all the lime. he evaporated the liquid to the consistency of honey. The thickened acid was redissolve in rectified alcohol, which eliminated the milk sugar and many other materials. The alcohol was removed by distillation.-

[The inaccurate work of Bouillon-Lagrange and several others confused the study of its properties; this resulted in 1813 in Braconnot's describing as if new, under the bizarre name of acid of Nancy or "nanceique acid", a product that was nothing else than Sheele's lactic acid.] Nevertheless, Braconnot's work is one of the most thorough of the numerous memoirs that have dealt with this acid. He found the acid in rice that had fermented under water; in beet juice that, having undergone viscous fermentation and alcoholic fermentation, becomes sour and yields lactic acid and mannite; in some sour water made of baker's yeast; finally in sour's milk and in Scheele's lactic acid. <sup>8</sup> (The composition of lactic acid was established by Messrs. Pelouze and J. Gay Lussac in 1853<sup>9</sup>) Later in 1841 Messrs Fremy and Boutron published a work meriting special mention in the history of this substance, {[for in it they described the method of prolonging the action of nitrogenous organic material on sugars, in such a way as to transform these sugars more completely into lactic acid. They noticed that the action of the casein was stopped by the lactic acid itself, and by saturating the liquid from time to time with bicarbonate of soda they were able to transform all the sugar in the milk. Messrs Pelouze and Geliz did better; they added chalk to the sweetened water and to the ferment. The chalk constantly maintains the neutrality without any need for supervision on the part of the experimenter. Then, by taking up again Braconnot's experiments and imitating those of Mr Colin on alcoholic fermentation, it was possible to make the sugar undergo lactic fermentation with the help of any of the nitrogenous plastic materials. (Indeed the conditions for the preparation and the production of lactic acid are well known to the chemists).] }

## **-section 3: the challenge that will transform a debilitated opinion into a triumphant theory and a nonentity into the sole cause of lactic acid-**

### **section 3a -one against all the others**

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<sup>7</sup> (note re inserted in text)

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### **-section 3 b- one entity in spite of all the others**

iii new yeast -its preparation- its properties-analogies and differences with brewer's yeast

7- {If one examines carefully an ordinary lactic fermentation, there are cases where one can find, on top of the deposit of the chalk and of nitrogenous material, [spots of a grey substance which sometimes form a layer (*formant quelquefois zone*) on the surface of the deposit.] At other times, this substance] is found adhering to the upper sides of the vessel, where it has been carried by the movement of the gases. When examined under (the microscope,) when one is not forewarned (*prévenu*), it is hardly possible to [distinguish it from casein, disaggregated gluten, etc.; in such a way that nothing indicates that it is a *special* (*spécial* separate in Conant) *material*, or that it was *produced during* the fermentation. Its apparent weight always remain *very little* as compared to that of the nitrogenous material originally necessary for the carrying out of the process. Finally, very often it is *so mixed* with the mass of casein and chalk} that there would be no reason to suspect its existence. It is *it* nevertheless *that plays the principal role*.] I am going to show, first of all, how to *isolate* it and to **prepare** it in a *pure* state.

### **-fourth section: the new entity - yeast of lactic acid- defined by succession of trials gains an essence**

8- {I extract the soluble part from brewer's yeast, by treating the yeast for some time with fifteen times its weight of water at the temperature of boiling water. The liquid, a complex solution of albuminous and mineral material, is carefully filtered <sup>10</sup>. About fifty to one hundred grams of sugar are then dissolved in each liter, some chalk is added, [and *a trace of the gray material* ]I have just mentioned from a good, ordinary lactic fermentation is sprinkled in; then

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<sup>10</sup> If it does not come through clear, it can easily be made limpid by bringing it to a boil with a little chalk or by adding a very little lime water or sucrate of lime, which produces an abundant precipitate. This precaution is almost always necessary when the yeast water has been prepared from yeast that has been in contact with much water for several days. Fresh yeast or that which is submitted to only one of tro washings by cold decantation gives a yeast water that is very limpid with filtration.

one raises the temperature to 30 or 35 degrees centigrade. It is also good to introduce a current of carbonic acid in order to expel the air from the flask, which is fitted with a bent exit tube immersed under water.} [On the very next day a lively and regular fermentation is manifest. The liquid, originally very *limpid*, becomes *turbid*; little by little the chalk *disappears*, while at the same time a *deposit* is formed that grows continuously and progressively with the solution of the chalk.] {The gas that is evolved is pure carbonic acid, or a mixture in variable proportions of carbonic acid and hydrogen. After the chalk has disappeared, if the liquid is evaporated, an abundant crystallization of lactate of lime forms overnight, and the mother liquor contains variable quantities of the butyrate of this base. If the proportions of chalk and sugar are correct, the lactate crystallizes in a voluminous mass right in the liquid during the course of the operation. Sometimes the liquid becomes very viscous.} In a word, (we have under our eyes a **clearly characterized** lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists).

9- {In this experiment the yeast extract can be replaced by an extract of any nitrogenous plastic substance, fresh or decomposed, as the case may be.} This limpid liquid, containing a nitrogenous substance in solution, is [*nothing but food*, (and in this respect *its origin is of little importance* provided it is of such a nature] as to facilitate the development of *the organized body*) (*corps organisé*) that *produces itself* and is gradually deposited.

10- Let us now consider [what are the *characteristics* of this substance, the production of which is *correlated* with phenomena pertaining to the denomination of lactic fermentation. When it has become a mass (*prise en masse*) it looks exactly like ordinary pressed or drained yeast. It is slightly *viscous*, and *gray* in color. {(Under the microscope), it appears to be formed of little globules or very short segmented filaments,} isolated or in clusters, which form irregular flakes resembling those of certain amorphous precipitates. -forgotten by Conant: The globules, *much smaller than* those of brewer's yeast, are swiftly agitated, when isolated, by (a brownian movement, that is, the movement that matter always undergoes when suspended in a liquid at a sufficient state of division)<sup>11</sup>.

-note 5- I do not assign a size to the globules. I think that at such a minuteness of matter, illusions produced by light on the edges of the globules lead to errors which are of the same order of magnitude as the measures themselves. It is nevertheless a point that other persons (more skilled than myself in microscopy) will resolve with a greater certainty.-

10 continued- {Washed by water through decantation, then diluted in pure sugared water, *it makes it acid* immediately, progressively (sic the french is grammatically incorrect), but very slowly, because the *acidity hinders* its action on sugar.} {If one makes the chalk intervene, which maintains the neutrality of the milieu, the transformation of sugar is sensibly *accelerated*, and in less than an hour the production of gaz is manifest and the liquor is rich in lactate and butyrate of lime in various quantities.} {When, on the other hand, there is some albuminoid matter adapted to the feeding of the substance, it *develops itself* and one crops (*recueille*) amounts that have **no other limits** than the weight of the sugar or that of the albuminoid matter.] It can be collected and transported for great distances *without losing its activity*, which is *weakened* only when the material is dried or when it is boiled in water. *Very little* of this yeast is necessary to transform a considerable weight of sugar. {These fermentations should preferably be carried on so that the material is protected from the air, so that they will not be *hindered* by vegetation of foreign infusoria.}

11- Here we find *all the general characteristics* of brewer's yeast, and these substances probably have organic structures that, (in a natural classification, place them *in neighboring species* or in two connected families).

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<sup>11</sup> (note reinserted in the text)

### -fifth section- lactic yeast and brewer's yeast compared-

12- All the chemists will be surprised at {the rapidity and regularity of lactic fermentation under the conditions that I have specified, that is, *when the lactic ferment develops alone*; it is often *more rapid* than the alcoholic fermentation of the same amount of material. Lactic fermentation as it is ordinary carried out takes much longer.} (This can easily be understood.) The gluten, the casein, the fibrin, the membranes, the tissues that are used contain an enormous amount of useless matter. More often than not these become a *nutrient* for the lactic ferment (only after putrefaction -alteration by contact with plant or animalcules-) that has rendered the elements soluble and assimilable.

13- There is another *characteristic that permits one to compare* (this new ferment with brewer's yeast): {if brewer's yeast instead of the lactic ferment *is sown in limpid*, sugared, albuminous liquid, brewer's yeast will develop, and with it, alcoholic fermentation, even though the other conditions of the operation remain unchanged.} One should not conclude from this that the chemical composition of the two yeasts is *identical* any more than (that the chemical composition [of two **plants** is the same because they grew in the same **soil**]).

14- Then there is the final *analogy* which I must not omit, namely, that {it is not necessary to have at hand some lactic ferment to prepare more:} *it originates spontaneously*, with as much facility as brewer's yeast, whenever *conditions* are favorable.<sup>12</sup>

-Note 6: I use this word to describe the fact, leaving entirely aside any judgment on the question of spontaneous generation. [(The lactic ferment *develops* in contact with common air if the *conditions* with respect to the medium and temperature are favorable.)] {If the experiment is carried out under conditions where the air is **excluded** or in the **presence** of air that has been previously heated, the process that takes place is the same as with brewer's yeast or infusoria, and under these conditions one can reproduce (the well known experiments of various physiologists who have repeated and made more precise the work of Appert and Gay-Lussac on the **influence of air** on the phenomena in question).}-

15- {If one dissolves some sugar in limpid yeast water, and adds chalk, fermentation will set in on the following day or the day after, and **because** the medium is neutral, it will tend to be *exclusively* a lactic fermentation. Sufficient contact with the air will take place during the mixing unless very particular precautions are taken (which I do not assume) and indeed it will be useless to prevent it. Nevertheless, it is preferable to sow a little lactic ferment in the liquid, for if one does not, there is apt to be a simultaneous development of several fermentations and that of animalcules which are very *injurious*.}

### -sixth section: understanding retrospectively what fermentations in general are

16- (Whenever an albuminous liquid of a suitable nature contains a substance such as sugar, capable of undergoing diverse chemical transformations [*dependent upon the nature* of such and such a ferment, the germs of these ferments *all tend* to propagate at the same time, and usually they develop simultaneously, unless one of the ferments *invades* the medium *more rapidly* than the others.]) It is **precisely** this last **circumstance** that {one determines when one use this method of sowing *a being that is already formed and ready to reproduce*.} If {no ferment is sown in a mixture of sugared water, albuminoid matter, and chalk, there generally are several parallel fermentations, with their respective ferments, and animalcules that seem to devour the little globules of these ferments. The addition of a *definite pure ferment* greatly assist the production of the corresponding fermentation, though without ensuring it in every case.} (What takes place in fermentations may be compared to what occurs in a plot of land that

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<sup>12</sup> (reintroduced in the text)

is not seeded. It soon becomes *crowded* with various plants and insects that are **mutually** harmful.)

17- (One of the essential conditions for good fermentations is the [*purity of the ferment*, its *homogeneity*, its *free development without any hindrance* and with the *help* of a nutrient well *adapted* to its *individual nature*.]) In this respect, it is important to realize that (the **circumstances** of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids play an important part in the predominant growth of such and such a ferment,) because [the *life* of each does not *adapt* itself to the same degree to different states of the *environment*.] {If some sugar is dissolved, for example, in very limpid yeast water without adding chalk and without sowing anything, one may be assured that two days hence the fermentation will be alcoholic, the yeast being deposited at the bottom of the vessel. However, in very rare cases, as has been proved to me at various times by numerous experiments, the ferment that develops will be lactic ferment}. I repeat, that is an exception if this happens, even though lactic ferment may previously been sown. This is because, under such conditions, the liquid may become acid, and acidity seems to weaken and interfere with lactic ferment more than it does with the alcoholic ferment. There is yet much research to be done in this direction.

18- If on the contrary {the medium is made neutral or a little alkaline the lactic ferment will have *a great tendency* to appear and then increase.} The definitive **proof** of this statement follows. {If one adds alkaline magnesia to sugared water an brewer's yeast, alcoholic and lactic fermentation will take place simultaenously with the formation of a crystalline precipitate of magnesium lactate;} a microscopic examination of the liquid shows the presence of a considerable quantity of the little globules of the lactic ferment mixed with the globules of brewer's yeast. These globules arise simultaneously from the albuminous liquid furnished by the soluble part of the brewer's yeast, as the alkalinity of the liquid considerably diminishes the activity of the yeast as an alcoholic ferment. A slightly alkaline medium is thus very convenient for the development of the new yeast, but it is also eminently *favorable* to the infusoria, which, by consuming the new globules or at least removing their source of nourishment often prove to be an insurmountable *hindrance* to this class of phenomena.

-omitted by Conant abd bl19- The brewer's yeast offer peculiarities of the same nature. (...)

-omitted by Conant translated by bl- 20- (The details in which I have just entered allow us to **anticipate** all the variations) to which fermentations could be subjected, and **in particular** the lactic fermentation, which *requires* a milieu the neutrality of which is also well adjusted for other vegetals and infusories. Even if one follows all the precautions I have indicated, {it often happens that complications arise and that there is coincidence of various phenomena.} We saw that it was the brewer's yeast that was the greatest hindrance. I had then to look for the proper circumstances that could stop its development without interfering notably with that of the lactic yeast. I hope I can succeed through the use of rough (*brut*) oignon juice as the albuminous medium. The essential oil (*huile essentielle*) of this juice completely hinders the formation of brewer's yeast; it seems also to be injurious to infusories. I will thus come back, in a special work, on the usefulness of this natural juice.

-21- Even though, through the use of oignon juice it would be impossible to solve the difficulty, that is to exactly trigger constantly and easily lactic fermentation without the complication of ferments and infusories foreign to the phenomena, all the facts that I have gathered lead me to believe that the most efficient mean to reach this result is to try to hamper (*chercher à nuire*) the production of parasitic ferments by means of particular substances. If one sows, for instance, fresh globules of brewer's yeast in the juice of oignon, never those globules will develop. They never trigger alcoholic fermentation. On the other hand, if {one boils the oignon juice, which has for effect to separate the sulfur essential oil (*chasser l'huile essentielle sulfurée*), and may be to modify its albuminous principles, the brewers' yeast will develop in the cooled liquid with remarkable efficiency, and the sugar either of the juice or that one may have added, will be changed in alcohol and carbonic acid.} Thus, alcoholic fermentation never starts

spontaneously in the natural oignon juice, although it is as acid and grape juice, but it always undergo the lactic fermentation linked or not to various peculiarities upon which I will later call attention.-end of translation bl-

### **-section 7: a “matter” of life and death**

22- All through this memoir, I have reasoned on the basis of the **hypothesis** that the [*new yeast is organized*, that it is a *living organism*, and that its chemical *action* on sugar corresponds to its *development* and *organization*.] If someone were to tell me that in these conclusions I am going beyond that which the facts prove, I would answer that it is quite true, in the sense that the stand I am taking is in a framework of ideas (*un ordre d'idées*) that in rigorous terms cannot be irrefutably demonstrated. Here is the way I see it. (Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be inclined to assign their primary cause to a type of reaction consistent with the general results of his own research. It is the logical course of the human mind in all controversial questions.) And it is, in my opinion, at this point in the development of my knowledge of the subject, that whoever judges impartially the results of this work and that which I shall shortly publish will recognize with me that [fermentation appears to be *correlative* to *live* and to the *organization* of globules, and not to their *death* and *putrefaction*.] no more than [fermentation is a phenomenon due to *contact* in which the transformation of sugar would take place in the presence of the ferment *without* giving up anything to it or *taking* anything from it]. These latter facts, as we will see shortly, are contradicted by experiments.

23- In a work that will follow shortly, I shall take up the chemical action of the new yeast on sweetened substances.

## (ORGANIZATION OF THE TEXT)

- section one: (corresponds to part I) framed by #1 and 3 that repeats the same worry about drift except the #1 talks about direct connection and the #3 only expects that new work will show the connection; the section explains the metanarrative and creates the suspense offering an ethnoepistemology; there might be a ferment involved
- section two (corresponds to beginning of #4) recapitulates the procedure to obtain lactic acid as it is handed down by others
- section three (cut across II and III) and includes #7; the drama of the modification of lactic acid and of its champion is staged; what are they? nothing. What will they become? everything. It is defined by the end of #5 for the human character ("I have been led to an entirely different point of view") -section three a- and the end of #7 for the non human character ("it is nevertheless it that plays the principal role") -section three b-
- section four (from #8 to 11) defines the entity through an experientia princeps interpreted by "clothing" it with more and more essentialist properties- the section culminates with the possibility of attributing it a name in classification thus marking the polar opposite of the end of section 3 where it was a complete non-entity
- section five (from #12 to 15): now that the entity is well defined and has definite properties it can be compared to brewer's yeast as a competitor for nutrients -the notion of sowing is defined and since there is a competition the next section is prepared for a generalization of the conditions - by the word "injurious".
- section six (from #16 to 21) generalises to the practice of fermentation and of the methods to ensure purity and control of circumstances -shift out to a story of helpers and hinders which transforms medium into environment
- section seven (#22) justifies the metanarrative that goes beyond the fact and challenges the alternative cosmology of Liebig

## MODIFICATION OF ACTANTS

### HUMANS

- 1- the author went straight, make a surprising turn, but in fact goes straight from one problem to the next (DOUBLE SUSPENSE why does he change? if he changes so much why is it so direct?)
- 4-bis everyone knows how to make lactic acid BUT ignores entirely the mode of action (conflict between two conflicting properties knowing how to do but not why; SUSPENSE and even DRAMATISATION)
- 5- all the authorities Liebig, Berzelius, Berthollet Fremy, are ironically made antagonists and will be reversed by one different point of view; all agree but "i have been led to an entirely different point of view" (DRAMATIZATION)
- 7- heroicisation of the unnamed observer able to detect the invisible object x into the lactic fermentation ("when one is not forewarned it is hardly possible" - thus the one can do that is transformed from an impotent to a potent observer). Hence the end of the # "i am going to show" which is in contradiction with the lost observer (DRAMATIZATION)
- 22- "And it is, in my opinion, at this point in the development of my knowledge of the subject, that WHOEVER judges impartially the results of this work and that which I shall shortly publish WILL RECOGNIZE WITH ME that " (the audience is convinced and sanction the author)

## NON-HUMANS

### *TRANSFORMATIONS OF ACCESSORY ENTITIES*

#### *two amyl acohols*

- 2- QUANTITY: amyl alcohol was ONE it is now TWO one LEFT one RIGHT
- 2- ORIGIN: amyl alcohol asymmetry comes FROM sugar; IMPOSSIBLE INHERITANCE TOO DISTANT FROM SUGAR; action "promptly disappears" asymmetry comes from SOMETHING ELSE (SUSPENSE who is it if it not the sugar?, but this suspense is added to the principal one)  
lactic acid
- 4- ESSENCE: lactic acid is discovered and produced through a stabilized procedure described in a stylized series of verbs in note 1; (it is not a transformation but since it is a base line on which the transformation is going to be recognizable it is important to list it here)
- 4-TWO entities Sheere's lactic acid and Bouillon-Lagrange's nanceic acid are made ONE
- 4- SAME lactic acid is found in MANY PLACES rice, beet juice, sour water of kaber'es yeast (the entity is stable and its extension is greater)
- 4- other experimenters have transformed process of lactic acid from INTERRUPTED and INCOMPLETE to ININTERRUPTED and COMPLETE AUTOMATICALLY (it is not clear if this is a proeprty of the entity or a quality of the experiment probably of the experiment the entity being left stable)

#### *Liebig's cosmology*

- 5- Liebig's theory defines a type of entity "[a ferment is an excessively alterable substance that decomposes itself and thereby excites fermentation in consequence of its alteration by disrupting through communication and by disassembling the molecular group of the fermentable matter.)"] (again it isnot a transformation but the backdrop against which the new entity is going to appear and out of which the properties are going to be reshuffled and reattributed)
- 22- "[fermentation appears to be correlative to live and to the organization of globules, and NOT to their DEATH and PUTREFACTION,]"
- 22- "no more than [fermentation is a phenomenon due to CONTACT in which the transformation of sugar would take place in the presence of the ferment WITHOUT giving up anything to it or taking anything from it]." (perfect challenge with the definition of Liebig ANTI-PROGRAMME
- 22- These latter facts, as we will see shortly, are contradicted by experiments.
- 23- "In a work that will follow shortly, I shall take up the chemical action of the new yeast on sweetened substances" (Liebig will be defeated together with its theory)

#### *brewer's yeast and alcoholic fermentation*

- it goes from being the only case to being one case of yeast in competition with the new one and in competition with it
- 6- "I plan to show that (just as an alcoholic ferment exists, namely, brewer's yeast, which is found wherever a sugar breaks down into alcohol and carbonic acid,) so too [there is a special ferment, a lactic yeast,"
  - 8- "{I extract the soluble part from brewer's yeast, by treating the yeast for some time with fifteen times its weight of water at the temperature of boiling water."
  - 10- "The globules, much smaller than those of brewer's yeast,"
  - 11- "we find all the general characteristics of brewer's yeast, and these substances probably have organic structures that, (in a natural classification, place them in neigboring species or in two connected families)"

- 13- {if brewer's yeast instead of the lactic ferment is sown in limpid, sugared, albuminous liquid, brewer's yeast will develop, and with it, alcoholic fermentation, even though the other conditions of the operation remain unchanged.}
- 13- "One should not conclude from this that the chemical composition of the two yeasts is identical any more than (that the chemical composition [of two plants is the same because they grew in the same soil]).
- 14- "Then there is the final analogy which I must not omit, namely, that {it is not necessary to have at hand some lactic ferment to prepare more:} it originates spontaneously, with AS MUCH facility as brewer's yeast, whenever conditions are favorable. "
- 17- "This is because, under such conditions, the liquid may become acid, and acidity seems to weaken and interfere with lactic ferment MORE THAN it does with the alcoholic ferment. "
- 19- on yeast by opposition to lactic acid
- 20- "I had then to look for the proper circumstances that could stop its development without interfering notably with that of the lactic yeast. I hope I can succeed through the use of rough (brut) oignon juice as the albuminous medium" (oignon juice allows to DISCRIMINATE between the two RIVALS and to limit one without limiting the other)
- 21- "alcoholic fermentation never starts spontaneously in the natural oignon juice, although it is as acid and grape juice, BUT it always undergoes the lactic fermentation"

### *medium*

- 9- {In this experiment the yeast extract can be replaced by an extract of any nitrogenous plastic substance, fresh or decomposed, as the case may be.} This limpid liquid, containing a nitrogenous substance in solution, is [nothing but food, (and in this respect its origin is of little importance provided it is of such a nature) as to facilitate the development of the organized body) (corps organisé) that produces itself and is gradually deposited." (crucial change since the CAUSE becomes the FOOD OF THE CAUSE and the MEDIUM is now defined as a plot of land favorable or not to an organism)
- 17- "In this respect, it is important to realize that (the circumstances of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids PLAY an important PART in the predominant growth of such and such a ferment,) because [the life of each does not ADAPT itself to the same degree to different states of the ENVIRONMENT.]" ( a medium is now an environment)
- 18- "if on the contrary the medium is made neutral or a little alkaline the lactic ferment will have a great tendency to appear and then increase."
- 21- ""all the facts that I have gathered lead me to believe that the most efficient mean to reach this result is to try to hamper (chercher à nuire) the production of parasitic ferments by means of particular substances." (corresponds to a new definition SUBSTANCE becomes ANTIBIOTICS)
- 22- "its chemical action on sugar corresponds to its development and organization." (chemical ACTION is thus the consequence of DEVELOPMENT)

### *air*

- 14- " it originates spontaneously, with as much facility as brewer's yeast, whenever conditions are favorable"
- 14- note 6: "under conditions where the air is excluded or in the presence of air that has been previously heated, the process that takes place is the same as with brewer's yeast or infusoria, and under these conditions one can reproduce (the well known experiments of various physiologists who have repeated and made more precise the work of Appert and Gay-Lussac on the influence of air on the phenomena in question).}" (interesting to see how a marginal object cited in foot note is alluded to and starts to be disentangled in to TWO as bearer of the new entity and as common air through heating)

- 15- "Sufficient contact with the air will take place during the mixing unless very particular precautions are taken (which I do not assume) and indeed it will be useless to prevent it."
- 16- "a plot of land that is not seeded. It soon becomes crowded with various plants and insects that are mutually harmful" (air is not named but the metaphor of the land allows the modification of air as well)  
chemical circumstances
- 17- "the circumstances of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids PLAY AN IMPORTANT PART in the predominant growth of such and such a ferment" (these well known chemical properties take a new meaning since they are now CONDITIONS of an ENVIRONMENT to beings to ADAPT to it)
- 18- "if on the contrary the medium is made neutral or a little alkaline the lactic ferment will have a great tendency to appear and then increase."
- 18- "A slightly alkaline medium is thus very convenient for the development of the new yeast, but it is also eminently favorable to the infusoria, which, by consuming the new globules or at least removing their source of nourishment often prove to be an insurmountable hindrance to this class of phenomena." (they are now treated as HELPER or HINDERER of the development)

## MAIN CIRCULATING OBJECT -YEAST OF LACTIC ACID

### *MAIN CIRCULATING OBJECT- as OBJECT (x)*

- 2- INNOVATION: " what [the influence of a ferment might be] in" (first allusion to the x)
- 2- CAUSE: molecular asymmetry "plays a role" in the most intimate laws of organization and intervenes in their most hidden characteristics (SUSPENSE since role is enormous but unknown so the lactic acid is held by this huge QUEST that dominates the whole narrative)
- 4-bis CAUSE of mode of action entirely unknown (SUSPENSE it is known how to make lactic acid but no cause for it is perceptible)
- 4bis- ANTI-INNOVATION entity is invisible and when it is there it is detrimental and spoils "researches have been unable to discover the development of organized beings. Observers who have recognized some of those beings have at the same time established that they were accidental and spoiled the process." (SUSPENSE and beginning of DRAMATISATION: if it is absent how can it cause?) (anti x)
- 5- Liebig's theory defines a type of entity "[a ferment is an excessively alterable substance that decomposes itself and thereby excites fermentation in consequence of its alteration by disrupting through communication and by disassembling the molecular group of the fermentable matter.)"] this is the ANTIPROGRAMME of the ferment against which the DRAMATISATION is going to be made - there is a dispute among them on the attribution of properties
- 5- "all agree to reject the [ idea of some sort of influence from organization and life as a cause of the phenomena that we are considering.] (third irruption of the entity x to be defined PRE DRAMATISATION through this ANTI-ESSENCE)  
"(just as an alcoholic ferment exists, namely, brewer's yeast, which is found wherever a sugar breaks down into alcohol and carbonic acid,)" (it is both a borrowing and a redefinition since the metaphor is going to be used to attribute properties to the newly emerging entity)
- 6- EXISTENCE "there is a special ferment"
- 6- REDISTRIBUTION OF PROPERTIES "Nitrogenous plastic is food for its development NOT its origin" (one part of Liebig's property is transformed and reattributed or reconstituted in food)
- 7- INNOVATION NEW SENSE DATA: the entity is defined by primary sensitive quality leading back to perception and sense data, [spots of a grey substance which sometimes form a layer (formant quelquefois zone) on the surface of the deposit.] At other times, this

substance] is found adhering to the upper sides of the vessel, where it has been carried by the movement of the gases. (uncertainty on its very perceptual qualities)

(depending on the level of uncertainty we get either whole package of experiments-theories-routine summarised in a common name, or, as in the case here, we are led back to the sensory qualities out of which the new entity is going to be "clothed")

7-ANTI-ESSENCE [indistinguishable from casein, disaggregated gluten, etc.; NOT a special (special separate in Conant) material, NOT produced during the fermentation. Its apparent weight always remain VERY LITTLE as compared to that of the nitrogenous material originally necessary for the carrying out of the process. Finally, very often it is so MIXED with the mass of casein and chalk}] (still part of the DRAMATIZATION the author adds antiquities to render the existence still more vivid)

7 " that there would be no reason to suspect its existence. It is it nevertheless that plays the principal role"

7- it so real that it can be ISOLATED, PURIFIED and PREPARED (but in this # it is still a claim)

### ***MAIN CIRCULATING OBJECT - as NEW SENSE DATA***

7- INNOVATION NEW SENSE DATA: the entity is defined by primary sensitive quality leading back to perception and sense data, [spots of a grey substance which sometimes form a layer (formant quelquefois zone) on the surface of the deposit.] At other times, this substance] is found adhering to the upper sides of the vessel, where it has been carried by the movement of the gases. (uncertainty on its very perceptual qualities)

10- "When it has become a mass (prise en masse) it looks exactly like ordinary pressed or drained yeast. It is slightly viscous, and gray in color. {(Under the microscope), it appears to be formed of little globules or very short segmented filaments,} isolated or in clusters, which form irregular flakes ressembling those of certain amorphous precipitates. - forgotten by Conant: The globules, much smaller than those of brewer's yeast, are swiftly agitated" (although it is in #10 we are led back to sense data but this time with the certainty that it is an agent -so instead of perceptions without substrate as in #7 we now have a substrate made visible through the experiment)

### ***MAIN CIRCULATING OBJECT - as NAME OF ACTIONS***

8- "[and a trace of the gray material ]I have just mentioned from a good, ordinary lactic fermentation is sprinkled in" (TRIAL if a trace is enough to start a good fermentation the object x -will not only be a grey substance- but will also be a ferment similar to brewer's yeast -this is a Hacking's type of realism "if it can be sprinkled it exists") (the GESTURE defines the entity)

8- "[On the very next day a lively and regular fermentation is manifest.] The liquid, originally very limpid, becomes turbid; little by little the chalk disappears, while at the same time a deposit is formed that grows continuously and progressively with the solution of the chalk" (it is not only the success of the experiment but the link with the sprinkling of the gray substance) (the action is defined by all the characteristics of a lively fermentation which is soon to be attributed to one cause)

9- ANTI-ESSENCE: REVENGE and REDISTRIBUTION OF PROPERTIES "This limpid liquid, containing a nitrogenous substance in solution, is [NOTHING BUT FOOD, (and in this respect its ORIGIN is of LITTLE IMPORTANCE provided it is of such a nature]" (this is the anti#7 since now the medium which was to be the cause of an invisible nothing is now itself NOTHING BUT food and its orgini which was so important is now of NO importance -so the former entity -Liebig's one is now as destituted as the entity x was in #7)

### ***DEFINITION OF THE ENTITY IN THE #10***

10- "what are its CHARACTERISTICS"

CAUSE OR CONNECTION "its production is correlated with phenomena pertaining to the denomination of lactic fermentation" (there is in this # a sort of restrain in attributing essence)

RESEMBLANCE "When it has become a mass (prise en masse) it looks exactly LIKE ordinary pressed or drained yeast. It is slightly viscous, and gray in color." (back to sense data -but the order is reversed it is now a being which manifests its secondary qualities - and no longer perceptions in search for a substrate)

SHAPE AND SIZE "{(Under the microscope), it appears to be formed of little globules or very short segmented filaments,} isolated or in clusters, which form irregular flakes resembling those of certain amorphous precipitates. The globules, much smaller than those of brewer's yeast, are swiftly agitated, when isolated," (although it is at the limit of precision it is now granted a form if not a size)

ACTION ON "it makes sugared water acid" (we now move not only to qualities but to competences -its slightly more than a name of action since we can now infer that it DOES this because it IS this)

REQUIREMENTS "it accelerates" action if alkalinity maintained

HELPERS and HINDERS "albuminoid matter adapted to the feeding of the substance, it develops itself"

FRAGILITY AND SOLIDITY "It can be collected and transported for great distances without losing its activity, which is weakened only when the material is dried or when it is boiled in water." (we are still so close from the name of action that it has to be tried since the experimenter does not yet know what counts so the ENVELOP is not yet drawn)

POWER "very little of this yeast is necessary to transform a considerable weight of sugar".(striking reversal of SIZE and FORCE -and in complete opposition with #7)

COMPETITION 'so that they will not be hindered by vegetation of foreign infusoria"

11- TAXONOMIC TREE" Here we find all the general characteristics of brewer's yeast, and these substances probably have organic structures that, (in a natural classification, place them in neighboring species or in two connected families)" (the substance could now be so well defined that it could have a place and a NAME in a TAXONOMY whereas 3 paragraphs before it was so uncertain that it did not exist)

### ***MAIN CIRCULATING OBJECT -AS FULL BLOWN ENTITY***

12- "when the lactic ferment develops ALONE" (it is now an existence so sure of itself that conclusion will be drawn on the former practices and it is granted new REQUIREMENTS)

13- its characteristics compare to brewer's yeast (METAPHOR bringing in again the ontological model already in place for brewer's yeast with the added property of COMPETITION)

12- "nutrients" (now there has been a reversal of properties -everything is explained by the medium being a nutrient instead of being the cause of the emergence of the entity)

13- brewer's yeast "is sown in" (SOWING it in a PURE medium is a proof of existence and mastery)

13- two plants growing in the same soil" (METAPHOR again which renders familiar the type of existence of the new entity and which is going to produce other questions -Hesse's positive type- what are its nutrients? what parasites it? etc)

14- " Then there is the final ANALOGY which I must not omit, namely, that {it is not necessary to have at hand some lactic ferment to prepare more:} (again using the brewer's yeast already existing entity as AN ANALOG to grant properties to the new yeast)

14- " it originates SPONTANEOUSLY, with as much facility as brewer's yeast, whenever conditions are favorable" (the word is qualified in the foot note as indicating AIR plus FAVORABLE CONDITIONS -so now one can turn back to the air to disentangle it)

- 14- note 6: "The lactic ferment develops in contact with common air if the conditions with respect to the medium and temperature are favorable." (it is now so grown up that AIR can be added to the CONDITIONS of its growth)
- 15- "it will tend to be exclusively a lactic fermentation" if not other fermentations are "injurious" (so it is in COMPETITION with others for the same rare resources)
- 22- "[new yeast is ORGANIZED, that it is a LIVING organism, and that its chemical ACTION on sugar corresponds to its DEVELOPMENT and organization.]" (most precise definition of the lactic acid in its CLOTHING) (comes back to the definition of lactic yeast as a particular)

### **MAIN CIRCULATING OBJECT- MERGED INTO A CLASS**

- 16- "[dependent upon the NATURE of such and such a ferment, the germs of these ferments all TEND to propagate at the same time, and usually they develop simultaneously, unless one of the ferments INVADES the medium more rapidly than the others.]" (it is now integrated in a CLASS of phenomena with COMMON properties and TENDENCIES in COMPETITION)
- 16- "It is precisely this last circumstance that one determines when one use this method of sowing a being that is already FORMED and READY TO REPRODUCE".
- 16- "The addition of a definite PURE FERMENT greatly assist the production of the corresponding fermentation"
- 16- "a plot of land that is not seeded. It soon becomes CROWDED with various plants and insects that are mutually harmful" (again the reimport of a METAPHOR allows solidification and coalescence of the being and introduces the new feature of CROWDING which is going to become so important in the part on s g)
- 17- "One of the essential conditions for good fermentations is the [PURITY of the ferment, its HOMOGENEITY, its FREE development without any HINDRANCE and with the HELP of a nutrient well ADAPTED to its individual nature.]" (probably the most important stabilisation of the entity generalized now to the practice of fermentation itself)
- 17- "[the life of each does not ADAPT itself to the same degree to different states of the environment.] " (they are all now collectively granted ADAPTATION to ENVIRONMENT abilities modifying the definition of the medium as well)
- 18- "A slightly alkaline medium is thus very CONVENIENT for the development of the new yeast, but it is also eminently FAVORABLE to the infusoria, which, by consuming the new globules or at least removing their source of nourishment often prove to be an insurmountable HINDRANCE to this class of phenomena."
- 20- "The details in which I have just entered allow us to anticipate ALL THE VARIATIONS to which fermentations could be SUBJECTED, and in PARTICULAR the lactic fermentation, which REQUIRES a milieu the neutrality of which is also well adjusted for other vegetals and infusories." (now the lactic acid is part of a research project and only a particular case)
- 22- ATTRIBUTION OF ACTANTIALITY "[new yeast is ORGANIZED, that it is a LIVING organism, and that its chemical ACTION on sugar corresponds to its DEVELOPMENT and organization.]" If someone were to tell me that in these conclusions I am going beyond that which the facts prove, I would answer that it is quite true," (summary of the ESSENCE of the YEAST inserted in a CLASS that goes beyond the FACT showing how the ontological properties are ATTRIBUTED to the BEING)
- 22- ESSENCE "[fermentation appears to be correlative to LIVE and to the ORGANIZATION of globules, and NOT to their DEATH and putrefaction,]" (summary and DRAMATIZATION again since now the whole text becomes a life and death matter)
- 22- ANTI-ESSENCE "no MORE than [fermentation is a phenomenon due to contact in which the transformation of sugar would take place in the presence of the ferment without GIVING UP anything to it or ANYTHING anything from it]." (reversal again of the anti-

essence summary of the paper, recapture of a fight against Liebig, redefinition of action instead of sugar sitting by ferment (passively) the ferment is ACTIVE

## GESTURES

- 12- "All the chemists will be surprised at {the rapidity and regularity of lactic fermentation under the conditions that I have specified, that is, when the lactic ferment develops alone; it is often more rapid than the alcoholic fermentation of the same amount of material. Lactic fermentation as it is ordinary carried out takes much longer.}" ( what is transformed here is a practice from ORDINARY to NEW
- 13- "sowing it in a limpid medium"
- 15- "Nevertheless, it is preferable to sow a little lactic ferment in the liquid, for if one does not, there is apt to be a simultaneous development of several fermentations and that of animalcules which are very injurious.}"
- 16- " It is precisely this last CIRCUMSTANCE that one DETERMINES when one use this METHOD of sowing a being that is already formed and ready to reproduce. If no ferment is sown in a mixture of sugared water" (this is the most important sentence for the gesture since it defines not only retrospectively as in #12, but as a THEORY DEFINED prospective METHOD nicely linking in one sentence a theory, a method and a being ready to develop. This
- 16- "The addition of a definite pure ferment greatly assist the production of the corresponding fermentation"
- 17- " One of the essential conditions for good fermentations is the [PURITY of the ferment, its HOMOGENEITY, its FREE development without any HINDRANCE and with the HELP of a nutrient well ADAPTED to its individual nature.]" (it is now the whole of FERMENTATION that is retrospectively understood in its conditions)
- 20- :The details in which I have just entered allow us to anticipate all the VARIATIONS to which fermentations could be SUBJECTED."

## ENUNCIATION

### ENUNCIATOR

#### *IN SECTION 1 present tense direct action*

in this section the enunciator is always present but as a constant organizer and planificator of research programs

- 1- "i feel" "I undertook" (responsability, initiative)
- 1- "until now" (temporal marker defining the turning point of the present work and text)
- 2- "in one of my recent communications to the academy" (engaged in a series of rprestigious dialogues with others ISOTOPY)
- 2- gives them a special value (to me)
- 2- I then resolved
- 2- sugars seems to me to be very different
- 2- I am loath to believe this
- 2- one tries to find (he does experiments)
- 2- a result that can be foreseen from my investigations (one can see continuity in a series)
- 2- I find that
- 2- I must confess (responsability, emotion)
- 2- my researches have long be dominated by (not alone, led by metanarrative, long time)

- 3- I subsequently hope to connect (there will be more coming - ISOTOPY) (contrary to the next section the time is active present centered and framed by what he just did and that he will just do)

***IN SECTION 2 shifted out in other characters***

in this section the first enunciator is never there but has withdrawn to let the others in space and time do the foregrounding of lactic acid

ACTORIAL and TEMPORAL SHIFTING OUT

- 4- Scheele
  - 4- Confusing role of Bouillon Lagrange
  - 4- thorough work of Braconnot
  - 4- The composition of lactic acid was established by Messrs. Pelouze and J. Gay Lussac in 1853
  - 4- Messrs Fremy and Boutron published a work meriting special mention in the history of this substance
  - 4- Pelouze et Geliz did better" " They noticed that" (shifting out with construction of another delegated experimental scene where the two scientists work)
- 1841  
1833  
1813  
1780 (there are dates through shifting and change of tense)

***IN SECTION 3a all the others against one the enunciator***

- 4-bis "everyone knows- but " We entirely ignore the mode of action of the nitrogeous plastic material"
- 4-bis no one "Until now minute researches have been unable to discover the development of organized beings"
- 4-bis "observers have established that organized beings not only do not exist but are detrimental and spoil"
- 4-bis "Until now" (important for the DRAMATISATION, now things are going to change rapidly)
- 5 "they all agree" "i have been led to an entirely different point of view" (we come back to the positioning of the enunciator of section 1)

***IN SECTION 3b heroic and absent***

the enunciator is back in and it has some heroic character against adversity

- 6-"In the first part I plan to show that" (explicit organizer of the text)
- 7- "if one examines carefully" (this one is P himself since there are now temporal marquers "there are cases" "at other times" and marquers of proximity and hands on practice"sometimes forms a layer" and of skill "carefully")
- 7- "at other times it is found" (the experimenter finds but not always)
- 7- "it is hardly possible to distinguish when not forewarned" (helper needed to see)
- 7- "no reason to suspect" (antihelper DRAMATIZATION we could have missed it)
- 7-" I am going to show how to" (explicit organization of narrative and experimental practice -recipe-)

***IN SECTION 4 present as hands on but absent***

in the whole section the enunciator is involved but not psychologised -it is the hand doing the experiment -constantly active but not present as in section 1- (except in the note 5)

- 8- I extract
- the liquid is carefully filtered
- it is dissolved (by someone)

- chalk is added
- the grey substance is sprinkled
- one raises the temperature
- air is introduced
- 8- if proportions are correct
- 8- one has under the eyes a clearly characterized
- 9- yeast can be replaced
- 10- it looks exactly like (which supposes a comparator establishing the relation and relating to a subjectivity)
- 10- it appears to be"
- 10- note 5- "I do not assign" " I think"
- 10- washed
- 10- diluted
- 10- "if one makes the chalk intervene" (actors delegates to another nonhuman the task of acting on the entity)
- 10- "there is some albuminous" (this is a minimalist presence of the enunciator but it is nevertheless an action of putting
- 10- is dried
- 10- is boiled
- 10- "it can be collected and transported" (by the one who tries out and test the property of the element x)
- 10- experiments should be carried out"

#### ***IN SECTION 5 (same as in 4)***

- 12-"Lactic fermentation as it is ORDINARY carried out takes much longer" (it is a much important TEMPORAL marker since it is what is going to separate past and present - before we did not know what we were doing -now we do)
- 13- "That permits one to compare"
- 13- "if brewer's yeast is sown"
- 13- "one should no conclude"
- 14- "I must not omit"
- 14- note 6 "i use this word puttling aside any judgment"
- 14- note 6 "if experiments is carried out"
- 15- "if one dissolves" "unless very particular precautions are taken"
- 15 - "I do not assume"

#### ***IN SECTION 6***

- 15- "it is preferable to sow"
- 16- "is sown"
- 16- "it may be compared"
- 17- "one may be assured"
- 17- "as has been proved to me"
- 17- "i repeat" (explicit intrusion of the text)
- 17- "much research is to be done"
- 20- "The details in which I have just entered allow us to ANTICIPATE all the variations"(temporal marker defining the future)- see "until now"
- 20- "we saw"
- 20- "I had then" "I hope I can succedd"

#### ***IN SECTION 7***

- 22- "all through this memoir" (anaphor to the writing of the memoirs)
- 22- "I have reasoned"
- 22- "I am going beyond" "I would answer"

- 22- The stand I am taking"
- 22- " the way I see it"
- 22- "a chemist" "he will be" (shifting out) (it is probably P especially with the qualification "having the good fortune of making an important contribution"
- 22- "And it is, in my opinion, at this point in the development of my knowledge of the subject
- 22- " These latter facts, as we will see shortly, are contradicted by experiments".
- 23- "In a work that will follow shortly, I shall take up" (temporal marker indicating continuity and urgency)

## AUDIENCE

- 1-"it may seem surprising" (to an implicit audience who follow the author's with great attention)
- 2- I showed (to someone) in recent communications to the Academy
- 7- "I am going to show how to prepare and isolate it" (defines a community of readers equipped with similar skills)
- 12- "All the chemists will be surprised" (their complicated practice is becoming simple and easy)
- 17- "it is important to realize" (audience implied but not clearly)
- 20- "We saw that" (an audience has followed the text from at least the former section onward and it is common to the author and the readers)
- 22- "If someone were to tell me that" (return to the explicit wait of non specified audience)
- 22- 'that WHOEVER judges impartially the results of this work and that which I shall shortly publish will RECOGNIZE WITH ME" (the audience is not only explicitly acknowledge but its agreement with the writer is also granted at least in the future and once impartiality will have been obtained) (this audience is in a position to SANCTION the whole program of action and to recognize the DEFEAT of Liebig

## AGONISTS

- 2- certain preconceived ideas led me to dissent from the accepted opinion.
- 2- I repeat these were preconceived ideas. However, they were sufficient to persuade me
- 2- I must confess that my researches have long been dominated by the thought that section 2 could be considered in its entirety to be the agonists since they help the author define his experimental scenography
- 7- "when one is not forewarned it is hardly possible"

## ANTAGONISTS

- 2- contrary to what had been thought until then (by others unspecified scientists)
- 2- to dissent from the accepted opinion (of others)
- 4- inaccurate work of Bouillon-Lagrange and several others confused the study of its properties
- 5- facts entirely favorable to Liebig and Berzelius (they shift from undisputable authority to enemy through the use of ironic markers like 'seem, believe, according to") (their cosmology of Liebig is different and is painted as an ANTI-cosmology)
- 5- "These opinions gain more credit daily. In regard to this one can consult the Memoirs of Mrrss Fremy and Boutron on lactic fermentation, the pages dealing with fermentation and ferment in the excellent work that Mr gerhardt left when he died and Mr Bertholet's very recent memoir on alcoholic fermentation. These works all agree in rejecting the idea" (ironic markers again excellentm very recent)

- 7- "hardly possible to distinguish it" "nothing indicates that is a special material" "there would be no reason to suspect its existence (DRAMATIZATION, the enemies win, only the conditional "would" indicates the victory)
- 9- the yeast extract may be replaced, it is nothing but food, origin of little importance (anti #7 and will be extended against Liebig in the next memoir where the yeast will be grown without organic matter at all thus reversing Liebig)
- 10 note 5- "illusions produced by light on the edges of the globules lead to errors "
- 12- "Lactic fermentation as it is ordinary carried out" (the chemists did not know what they were doing -now we can understand)
- 13- "one should not conclude" (possible antagonism inside oneself)
- 14- note 6: "leaving entirely aside any judgment on the question of spontaneous generation" (trace of a polemic in which he is not going to go now but present nonetheless)
- 22- "If someone were to tell me that in these conclusions I am going beyond that which the facts prove, I would answer that it is quite true" (imaginary objector to whom is granted acquiescence)

## UNDISPUTABLE STOCKED AUTHORITY

- 2- as all chemists agree amy alcohol comes from sugar
- 2- considering the present stage of our knowledge
- 2- it is always observed (by others? by P?) that these alcohols originate in the process of fermentation, this fact led me
- 4- Scheele discovered lactic acid in soured whey; his best procedure for
- 4- Braconnot most thorough work
- 4- Pelouze et Gay Lussac establishes composition
- 4- Messrs Fremy and Boutron published a work meriting special mention in the history of this substance
- 4- Indeed the conditions for the preparation and the production of lactic acid are well known to the chemists
- 4-bis "today everyone knows that by adding"
- 4-bis everyone ignores entirely the mode of action
- 4-bis minute researches (and implicitly researchers) have been unable
- 4bis observers have recognized that organized beings are detrimental
- 5- "These opinions gain more credit daily. In regard to this one can consult the Memoirs of Messrs Fremy and Boutron on lactic fermentation, the pages dealing with fermentation and ferment in the excellent work that Mr Gerhardt left when he died and Mr Bertholet's very recent memoir on alcoholic fermentation. These works all agree in rejecting the idea" (there is an ironic use of the notion of credit and agreement -see also excellent very recent -since they are going to be considered as enemy but the more enemies the more striking the victory)
- 7 "we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists" (authority recently stocked -in section 2 in fact-)
- 10 note 5- "It is nevertheless a point that other persons more skilled than myself in microscopy will resolve with a greater certainty"
- 14- note 6: "the well known experiments of various physiologists who have repeated and made more precise the work of Appert and Gay-Lussac on the influence of air on the phenomena in question"
- 22- "(Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be inclined to assign their primary cause to a type of reaction consistent with the general results of his own research. It is the logical course of the human mind in all controversial questions.)"

(chemistry plus inclination plus instinct plus logics plus human mind all define the authority of frame of mind)

## EXPERIMENTAL SCENOGRAPHY

### STYLISTED BACKGROUNDED EXPERIMENTAL TRIALS

2- for every time that one tries {exp} to find the optical activity of a substance in its derivatives, it promptly disappears (since we are not yet on the foreground the experiment is alluded to and not even stylized)

all of section 2 is an experimental procedure of different explicitation but as offering the base line of state of the art skills (it is different from stocked knowledge since it is rooted in practice but the practice is only alluded to briefly)

4- Scheele best procedure for obtaining lactic acid "(Note 1: First he reduced the whey to an eight of its volume by evaporation. He filtered it and saturated it with lime to precipitate the phosphate of lime. The liquid was then filtered and diluted with three times its weight of water; into this he poured oxalic acid drop by drop to precipitate all the lime. he evaporated the liquid to the consistency of honey. The thickened acid was redissolve in rectified alcohol, which eliminated the milk sugar and many other materials. The alcohol was removed by distillation.)

(black boxed but with much more actions stylized and without doubt on the substance thus defined by trials)

4- "The chalk constantly maintains the neutrality without any need for supervision on the part of the experimenter" (experimental detail that is new and alludes for the first time to the troubles and worries of the experimenter)

4- other experimenters have transformed process of lactic acid from INTERRUPTED and INCOMPLETE to ININTERRUPTED and COMPLETE AUTOMATICALLY (it is not clear if this is a property of the entity or a quality of the experiment; it is most probably part of the procedure to complete the experiment)

4-bis {Its weight does not change perceptibly. It does not become putrid. However, it becomes altered and is continually in an evident state of decomposition} (experiment alluded - balance, index, but not even stylized)

10- " {(Under the microscope), it appears to be formed of little globules or very short segmented filaments,}" (the experiment is only implied here most of it being backgrounded)

### FOREGROUND EXPERIMENT( UNIFIED) #7-8

does not appear before #7 where details of the experiments are linked to the uncertainty about the entity- but after #8 we have an allusion to a variety of experiments which are not unified in one narrative

7- "{If one examines carefully an ordinary lactic fermentation, there are cases where one can find, on top of the deposit of the chalk and of nitrogenous material, [spots of a grey substance which sometimes form a layer (formant quelquefois zone) on the surface of the deposit.] At other times, this substance] is found adhering to the upper sides of the vessel, where it has been carried by the movement of the gases. When examined under (the microscope,) when one is not forewarned (prévenu), it is hardly possible to [distinguish it from casein, disaggregated gluten, etc.; in such a way that nothing indicates that it is a special (special separate in Conant) material, or that it was produced during the fermentation. Its apparent weight always remain very little as compared to that of the nitrogenous material originally necessary for the carrying out of the process. Finally, very

often it is so mixed with the mass of casein and chalk}" (markers of proximity, temporal, hands on)

(but this scene, although more fleshed out than the former, is much less concrete than the following one since it is still partially backgrounded in the past of what the other observers will have seen- so its a transitional scene before considering the next one)

8- EXPERIMENT PRINCEPS {I extract the soluble part from brewer's yeast, by treating the yeast for some time with fifteen times its weight of water at the temperature of boiling water. The liquid, a complex solution of albuminous and mineral material, is carefully filtered . About fifty to one hundred grams of sugar are then dissolved in each liter, some chalk is added, [and a trace of the gray material ]I have just mentioned from a good, ordinary lactic fermentation is sprinkled in; then one raises the temperature to 30 or 35 degrees centigrade. It is also good to introduce a current of carbonic acid in order to expel the air from the flask, which is fitted with a bent exit tube immersed under water.}

much more details and much more personal involvement of the experimenters including the GESTURES -especially the sprinkling one that is so important for the definition of the entity

8- "we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists" (it is a characteristic although not easily reproducible experiment- but even in its accidents it is typical)

## FOREGROUND EXPERIMENT-DISTRIBUTED

9- {In this experiment the yeast extract can be replaced by an extract of any nitrogenous plastic substance, fresh or decomposed, as the case may be.} (the experiment is reconstituted after the entity takes shape since ANY food will now do -other possibilities are open for experience)

10-" {(Under the microscope), it appears to be formed of little globules or very short segmented filaments,}" (the experiment is only implied here most of it being backgrounded

10- "{Washed by water through decantation, then diluted in pure sugared water, it makes it acid immediately, progressively (sic the french is gramatically incorrect), but very slowly, because the acidity hinders its action on sugar.}

10- " {If one makes the chalk intervene, which maintains the neutrality of the milieu, the transformation of sugar is sensibly accelerated, and in less than an hour the production of gaz is manifest and the liquor is rich in lactate and butyrate of lime in various quantities.}

10- {When, on the other hand, there is some albuminoid matter adapted to the feeding of the substance, it develops itself and one crops (recueille) amounts that have no other limits than the weight of the sugar or that of the albuminoid matter.]

10- It can be collected and transported for great distances without losing its activity, which is weakened only when the material is dried or when it is boiled in water. very little of this yeast is necessary to transform a considerable weight of sugar. [These fermentations should preferably be carried on so that the material is protected from the air, so that they will not be hindered by vegetation of foreign infusoria.}

12- " {the rapidity and regularity of lactic fermentation under the conditions that I have specified, that is, when the lactic ferment develops alone; it is often more rapid than the alcoholic fermentation of the same amount of material. Lactic fermentation as it is ordinary carried out takes much longer.}" (It is now the experiments of the PAST which is reinterpreted using as a solid indicator the theory

13- "{if brewer's yeast instead of the lactic ferment is sown in limpid, sugared, albuminous liquid, brewer's yeast will develop, and with it, alcoholic fermentation, even though the other conditions of the operation remain unchanged.}"

- 14- "{it is not necessary to have at hand some lactic ferment to prepare more:} it originates spontaneously," (advantage which is now going to be turned against s g)
- 14- note 6 "{If the experiment is carried out under conditions where the air is excluded or in the presence of air that has been previously heated, the process that takes place is the same as with brewer's yeast or infusoria, and under these conditions one can reproduce (the well known experiments of various physiologists who have repeated and made more precise the work of Appert and Gay-Lussac on the influence of air on the phenomena in question).}" (turn immediately to the reproduction of other on s g) (proof of the link between the two)
- 15 - "{If one dissolves some sugar in limpid yeast water, and adds chalk, fermentation will set in on the following day or the day after, and because the medium is neutral, it will tend to be exclusively a lactic fermentation. Sufficient contact with the air will take place during the mixing unless very particular precautions are taken (which I do not assume) and indeed it will be useless to prevent it. Nevertheless, it is preferable to sow a little lactic ferment in the liquid, for if one does not, there is apt to be a simultaneous development of several fermentations and that of animalcules which are very injurious.}" (back to experimental details but in a still scattered way -one gets the impression of the great many controlling experiments varying the conditions)
- 16- "It is precisely this last circumstance that {one determines when one use this method of sowing a being that is already formed and ready to reproduce.}" "
- 16- "{If no ferment is sown in a mixture of sugared water, albuminoid matter, and chalk, there generally are several parallel fermentations, with their respective ferments, and animalcules that seem to devour the little globules of these ferments. The addition of a definite pure ferment greatly assist the production of the corresponding fermentation, though without ensuring it in every case.}"
- 17- "{If some sugar is dissolved, for example, in very limpid yeast water without adding chalk and without sowing anything, one may be assured that two days hence the fermentation will be alcoholic, the yeast being deposited at the bottom of the vessel. However, in very rare cases, as has been proved to me at various times by numerous experiments, the ferment that develops will be lactic ferment}"
- 18- "{If one adds alkaline magnesia to sugared water an brewer's yeast, alcoholic and lactic fermentation will take place simultaenously with the formation of a crystalline precipitate of magnesium lactate;}"
- 20- "{it often happens that complications arise and that there is coincidence of various phenomena.}"

## **AUTO-ORGANIZATION OF THE NARRATIVE**

### **EXPLICIT PROGRAM DEFINING SUCCESSIVE PARTS**

- 1-"how it came about that I undertook my study of fermentations. Having until now directed all my efforts toward attempting to discover the relations" (relations with the past and definition of a turnib point)
- 1- "I should take up subject"
- 2- "I then resolved to make a thorough study of the two amyl alcohols to determine, if possible, the causes"
- 2- "they were sufficient to persuade me (me déterminer) to study what [the influence of a ferment might be] in the production of the two amyl alcohols. "
- 3- "Such was the origin and the motive for the new experiments on fermentations"
- 3- "I SUBSEQUENTLY hope to connect the phenomena of fermentation with the molecular dissymmetry "

- 6- "in the first part of this work, I PLAN to show that (just as an alcoholic ferment exists, namely, brewer's yeast,"
- 7- "I am GOING to show, first of all, how to isolate it and to prepare it in a pure state"
- 20- "The details in which I have just entered allow us to ANTICIPATE all the variations)"
- 20- "We SAW that it was the brewer's yeast that was the greatest hindrance. I had THEN to look for.... I hope I can succeed through ... I will thus COME BACK, in a special work, on the usefulness of this natural juice.
- 21- "{one boils the onion juice, which has for effect to separate the sulfur essential oil (chasser l'huile essentielle sulfurée), and may be to modify its albuminous principles, the brewers' yeast will develop in the cooled liquid with remarkable efficiency, and the sugar either of the juice or that one may have added, will be changed in alcohol and carbonic acid.}"
- 22- "All through this memoir, I have reasoned on the basis of the hypothesis that"
- 22- "and that which I shall shortly publish"
- 22- These latter facts, as we will see shortly, are contradicted by experiments.
- 23- "In a work that will follow shortly, I shall take up the chemical action "

### **METANARRATIVE (SENDER)**

- 1- Having until now DIRECTED all my efforts toward attempting to discover the relations that exist among the chemical, optical and crystallographic properties of certain substances, with the objective of shedding light on their molecular constitution - (sudden CHANGE by contrast with this clearcut program)
- 2-my researches have long been DOMINATED by the thought that the constitution of compounds considered from the point of view of molecular symmetry or lack of sym"metry (all of other things being equal) plays a considerable role in the most intimate laws of organization of living organisms and intervenes in their most hidden physiologic characteristics. (ASYMMETRY LINKED TO LIFE) (definition of a quest in which is inserted lactic acid case)
- 3- "Such was the origin and the motive for the new experiments on fermentations" (it is necessary to replace lactic acid inside the general narrative)
- 4-bis the mode of action is unknown and no one has been able to show the development "Until now minute researches have been unable to discover the development of organized beings" (the generality of that claim is indispensable for the drama of its reversal to unfold)
- 5- facts seem favorable to Liebig and Berzelius ANTI-META NARRATIVE "According to Liebig, such is the primary cause of all fermentations and the origin of most contagious diseases." (it is also what sends them but the cosmology is entirely different; important sentence because the object of value -infectious disease- will be kept as the long term price of the QUEST and will define the strategy)
- 16- "Whenever an albuminous liquid of a suitable nature contains a substance such as sugar, capable of undergoing diverse chemical transformations dependent upon the nature of such and such a ferment, the germs of these ferments all tend to propagate at the same time, and usually they develop simultaneously, unless one of the ferments invades the medium more rapidly than the others.])" (although this is inserted in the fifth section it starts redefining a general thesis inside which all the experiments are going to be included as particular cases)
- 17- "There is yet much research to be done in this direction."
- 20- "The details in which I have just entered allow us to anticipate all the variations to which fermentations could be subjected, and in particular the lactic fermentation, which requires a milieu the neutrality of which is also well adjusted for other vegetals and infusories."

(important because it redefines the research program and integrates the lactic acid as a special case)

- 21- "all the facts that I have gathered lead me to believe that the most efficient mean to reach this result is to try to hamper (chercher à nuire) the production of parasitic ferments by means of particular substances." (it is not only subjection to variations that count but now a new invention ANTIBIOTICS)
- 22- " I am going BEYOND that which the facts prove, I would answer that it is quite true, in the sense that the stand I am taking is in a FRAMEWORK of ideas (un ordre d'idées) that in rigorous terms cannot be irrefutably demonstrated. Here is the way I SEE it. " (explicitly definition of the necessity of a metanarrative in which the phenomena are given a place and a role when there is a controversy and acceptance of that as a natural tendency of the human mind)
- 22- " will recognize with me that [fermentation appears to be correlative to live and to the organization of globules, and not to their death and putrefaction,] no more than [fermentation is a phenomenon due to contact in which the transformation of sugar would take place in the presence of the ferment without giving up anything to it or taking anything from it" (new theory which is sending the definition of the futur research program)

## REGISTRATION OF THE ENVIRONMENT

### BLACKBOXES DESTOCKED FROM ENVIRONMENT

#### *IMPORTED AS IS FROM FAR AWAY -BACKGROUND*

- 2-(rotating the plane of polarized light) (importation without qualification not even of the instrument -the polarizer but of the resulting phenomenotechnical physical law)
- 7- "under the microscope" (black box perfectly still)
- 10 - "under the microscope" (but a note of Conant says it is recent and a much more interesting note of P says that it is at the limit of instrument precision) (very important import of a well known fashion to define entity by shifting to microscopy)
- 10- note 5- It is nevertheless a point that other persons (more skilled than myself in microscopy) will resolve with a greater certainty.-
- 10- "(a brownian movement, that is, the movement that matter always undergoes when suspended in a liquid at a sufficient state of division)" (import of a blackboxed theory-practice- experiment)
- 13- "(that the chemical composition of two plants is the same because they grew in the same soil)." (what is reused here is not a theory or an instrument but a very popular resource for understanding entities -plants and culture) METAPHOR
- 14- note 6: "(the well known experiments of various physiologists who have repeated and made more precise the work of Appert and Gay-Lussac on the influence of air on the phenomena in question)."
- 16- "(What takes place in fermentations may be compared to what occurs in a plot of land that is not seeded. It soon becomes crowded with various plants and insects that are mutually harmful.)" (again the METAPHOR of a very common agriculture helps to make the transition and attribute properties)
- 17- "the circumstances of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids play an important part in the predominant growth of such and such a ferment," (basic chemistry imported as it but given a new impact since they become ENVIRONMENT for beings adapting to it)
- 22- "(Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be inclined to

assign their primary cause to a type of reaction consistent with the general results of his own research. It is the logical course of the human mind in all controversial questions.)" (psychology of science and epistemology plus disciplinary culture and human nature imported to explain the strength of prejudice)

### ***IMPORTED WITH QUALIFICATIONS***

- 2- ("law of hemihedral correlation") (but in quotation mark to indicate a grey box)
- 2- (since the property of optical activity is entirely due to an unsymmetric arrangement of elementary atoms) greybox coming from Pasteur's own previous work
- 2- "(it is always observed that these alcohols originate in the process of fermentation)" (unclear if it is P's original background greybox or blackboxed by others)
- 2- -contrast with what is not a blackbox but the metanarrative that is said to lead the whole story ; "molecular symmetry or lack of symmetry (all of other things being equal) plays a considerable role in the most intimate laws of organization of living organisms and intervenes in their most hidden physiologic characteristics" (but this is not known yet)
- 5- Liebig's theory Berzelius's theory (they are destocked but they are not blackboxed since facts only "seem favorable to the ideas of Liebig and Berzelius")"according to Liebig" "Berzelius believes"
- 5- " These opinions gain more credit daily. In regard to this one can consult the Memoirs of Messrs Fremy and Boutron on lactic fermentation, the pages dealing with fermentation and ferment in the excellent work that Mr Gerhardt left when he died and Mr Bertholet's very recent memoir on alcoholic fermentation. These works all agree in rejecting the idea" (not only there is an ironic use but the precision of the destocking becomes clearer since we are coming closer from the polemics, there are now pages and memoirs and a recent world of papers) (see the same enrichment of practice with experiments)

### ***IMPORTED AS BACKGROUND ADJACENT TO FOREGROUND***

- all of section 2 is drawing on background knowledge but this background knowledge is portrayed as practice based in experiment
- 4- -contrast with essence of lactic acid in section 2 where it is not the destocking of the environment but the constitution of the essence of a stable phenomenon through a stable procedure -list of verbs and stable entity-
  - 4- (The composition of lactic acid was established by Messrs. Pelouze and J. Gay Lussac in 1853)
  - 4- Indeed the conditions for the preparation and the production of lactic acid are well known to the chemists (this is an explicit definition of blackboxing) including the generalisation from names of chemists to the chemists that is to any skilled practitioner)
  - 4- "(Today everyone knows that by adding chalk to sweetened water plus a nitrogenous substance such as casein, gluten, animal membranes, fibrine, albumin, etc. the sugar is transformed (se transforme) into lactic acid.)"
  - "(just as an alcoholic ferment exists, namely, brewer's yeast, which is found wherever a sugar breaks down into alcohol and carbonic acid,)" the preexisting case of the greybox ferment-for-yeast is going to be used to stabilize the new ferment
  - 8- "(we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists)" (in fact it is in part an anaphore since the section 4 reuses as a black box what has been established in section 2 as a base line)
  - 11- "Here we find all the general characteristics of brewer's yeast, and these substances probably have organic structures that, (in a natural classification, place them in neighboring species or in two connected families)" (after the microscope appeal is made to the sturdier taxonomy so stabilised is the shape)

- 12 "More often than not these become a nutrient for the lactic ferment (only after putrefaction -alteration by contact with plant or animalcules-)" (import of a theory of putrefaction -Ps own?-)
- 13- "(this new ferment with brewer's yeast)" METAPHOR bringing the already known model of existence into the vicinity of the new yeast)

## **BLACKBOXES RESTOCKED IN THE ENVIRONMENT AND REIMPORTED**

- as can be expected this move begins late in the text once entity have taken shape -it is partially linked to the anaphore and the continuity of practice in one narrative
- 2- (since the property of optical activity is entirely due to an unsymmetric arrangement of elementary atoms) (greybox coming from Pasteur's own previous work which is partially restocked in the course of the memoir since it is validated by the paper)
- 8- "(we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists)" (in fact it is in part an anaphore since the section 4 reuses as a black box what has been established in section 2 as a base line)
- 9- " (and in this respect its origin is of little importance provided it is of such a nature as to facilitate the development of the organized body)" (as soon as the entity takes shape it is used to remove a constrain from the environment and open another one -any proteine will do)
- 12-"Lactic fermentation as it is ordinary carried out takes much longer.} (This can easily be understood.) " (the new phenomenon becomes the solid balckbox which is going to explain retrospectively why it was difficult to perform the experiments in the past)
- 14- note 6 "[The lactic ferment develops in contact with common air if the conditions with respect to the medium and temperature are favorable.]" (air can now be untangled and modified since the ferment is now a full blown being with specific requirements)
- 16- '(Whenever an albuminous liquid of a suitable nature contains a substance such as sugar, capable of undergoing diverse chemical transformations dependent upon the nature of such and such a ferment, the germs of these ferments' "It is precisely this last circumstance that one determines when one use this method of sowing a being that is already formed and ready to reproduce." (generalisation to the whole case and immediate reimport to understand the gesture of sowing)
- 17- "(One of the essential conditions for good fermentations is the [purity of the ferment, its homogeneity, its free development without any hindrance and with the help of a nutrient well adapted to its individual nature.]) In this respect, it is important to realize that the circumstances of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids play an important part in the predominant growth" (generalization to the whole fermentation and then used immediately to redefine circumstances)

## **BLACKBOXES EXPORTED AND STOCKED INTO THE ENVIRONMENT**

- 10- "Here we find all the general characteristics of brewer's yeast, and these substances probably have organic structures that, (in a natural classification, place them in neighboring species or in two connected families)" (no sooner is the entity given reality that it is stocked in the world of natural history waiting for a name)
- 16- "(Whenever an albuminous liquid of a suitable nature contains a substance such as sugar, capable of undergoing diverse chemical transformations [dependent upon the nature of such and such a ferment, the germs of these ferments all tend to propagate at the same time, and usually they develop simultaneously, unless one of the ferments invades the

medium more rapidly than the others.])" (registration of a new definition of entities with nature and feeding requirements)

- 16- " It is precisely this last CIRCUMSTANCE that one DETERMINES when one use this METHOD of sowing a being that is already formed and ready to reproduce" (registered in the environment as a METHOD determining at will circumstances and tied to a theory)
- 17- "(One of the essential conditions for good fermentations is the [purity of the ferment, its homogeneity, its free development without any hindrance and with the help of a nutrient well adapted to its individual nature.])"
- 21- "Il the facts that I have gathered lead me to believe that the most efficient mean to reach this result is to try to hamper (chercher à nuire) the production of parasitic ferments by means of particular substances. " (the notion of antibiotics is registered into the environment)
- 22- "everyone will recognize with me that [fermentation appears to be correlative to live and to the organization of globules, and not to their death and putrefaction,] no more than [fermentation is a phenomenon due to contact in which the transformation of sugar would take place in the presence of the ferment without giving up anything to it or taking anything from it]" (so the impartial audience satisfied by P in spite of going beyond the facts has now a clear idea of the essence of thiswhole class of phenomenon and has defeated Liebig)

## ETHNO-EPISTEMOLOGY

- 1- a subject seemingly remote from prior studies may nevertheless be directly related to it
- 2- exception to a law give value and force author to resolve to study thoroughly
- 2- preconceived ideas lead to research program especially when reinforced by facts "and this fact was one more invitation to press on (persévérer) toward a solution of these problems"
- 3- "But as often happens in similar circumstances, my work grew little by little and deviated from the its original direction in such a way that the results that I am publishing today seem alien to my previous studies" (progressive drift of researches make them look different but it is okay and will be later reconected)
- 4- discoveries are made (in daily occurrences )"lactic acid was discovered in soured whey"
- 5- facts are favorable to alternative theories of Liebig and Berzelius
- 5- no matter how many authorities embrace a theory, one can be led to a different opinion "but I have been led to another"
- 7- without preconceived idea it is impossible to suspect the presence of an observation (antipositivism) " When examined under (the microscope,) when one is not forewarned (prévenu), it is hardly possible to [distinguish it " "very often it is so mixed with the mass of casein and chalk that there would be no reason to suspect its existence. "
- 12- Knowing what are the entities allow to look back on past experiment to understand their erratic behavior "Lactic fermentation as it is ordinary carried out takes much longer.} (This can easily be understood.) "
- 14 note 6: Facts and judgement may be separated "I use this word to describe the fact, leaving entirely aside any judgment on the question of spontaneous generation. " (this model is not the same as the others in #7 where a preconveided idea was necessary to achieve readings)
- 16- As soon as a general account is provided, sense is made of an experiment which is then retrospectively highlighted and then explicitly acknowledge as a method -"usually they develop simultaneously, unless one of the ferments invades the medium more rapidly than the others.]) It is precisely this last circumstance that {one determines when one use this method of sowing a being that is already formed and ready to reproduce.}"-
- 18- Statement may ne sufficiently proven by experiment narrative "The definitive proof of this statement follows."

- 22- Hypothesis are necessary. "I have reasoned on the basis of the hypothesis "
- 22- Explicit philosophy to justify investing the new yeast with activity, appeal to psychologism and instinct to fill in the gap between facts and interpretations -antipositivism."If someone were to tell me that in these conclusions I am going BEYOND that which the facts prove, I would answer that it is quite true, in the sense that the STAND I am taking is in a FRAMEWORK of ideas (un ordre d'idées) that in rigorous terms CANNOT be irrefutably demonstrated. Here is the way I see it. (Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be INCLINED to assign their primary cause to a type of reaction CONSISTENT with the general results of his own research. It is the LOGICAL course of the human mind in all controversial questions."

## DISCIPLINE

- 1- from chemical, optical crystallographic properties to physiologic chemistry
- 9- "well known to chemists"
- 10 note 5- It is nevertheless a point that other persons more skilled than myself in microscopy will resolve with a greater certainty
- 11- natural classification appealed to compare yeasts
- 22- "Whenever a chemist makes a study of these mysterious phenomena"

VERY ROUGH DRAFT  
ENGLISH UNCORRECTED

## A “matter” of life and death -or should we avoid hylozoism\*

### What is so wrong with actor-network theory?

Those of us who are engaged in some interdisciplinary work in the field of science studies have to develop intellectual resources that are adjusted to the contradictory demands of at least four disciplines, i.e. history, philosophy, sociology and anthropology of science and technology (I leave aside economics for the moment). One way to establish durable linkages would be to synthesize those disciplines and to integrate them in a powerful narrative about the way sciences and technologies have developed since the Greek to the present. No one has succeeded in such a task so far. Instead of a powerful synthesis or an overarching metatheory, Michel Callon and I believed possible to tackle the same task through the back door, so to speak, by looking for the weakest infratheory possible.

What is called “actor-network theory” has often been misunderstood because of this paradoxical strategy: expecting the largest number of connections from the weakest vocabulary.

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\* For two consecutive years I have tired my Science Studies students and colleagues at UCSD with the philosophy, sociology, history and anthropology of the Pouchet-Pasteur debate. I have enormously learned from all of them and if I have persisted in my sins it is not for their want of trying to amend me. I also thank Simon Schaffer for opening this debate and Adrian Cussins for many hours of stimulating discussion.

“How could they account, say its many critics, for the rich historical diversity, for the thick ethnographical descriptions, for the complex epistemological puzzles, for the pressing sociological problems, by rattling a few empty words like association, substitution, weaker and stronger force, ally, enrolment, network, trial etc.?” The answer is that we cannot. It is because this vocabulary is so poor, so empty, so repetitive, that we like it since there is not the slightest danger of ever being confused with the subject matter of history, philosophy, sociology and anthropology. This vocabulary does not aim at describing or at explaining, but at creating the relativist space in which the actors themselves may be deployed.

The situation is similar to that of three dimensional perspective space in the Renaissance. A young apprentice might have started by laying out the grid like framework of perspective, but had he stopped there no picture would yet have been offered to the eye, only a figure for a treatise on perspective. Slowly, stroke after stroke, the perspective grid is covered, hidden, superseded. What was then the use then of those vanishing points, horizon lines, and other empty signs? They provided the apprentice with a graphic and intellectual space in which the two dimensional canvass could welcome, accommodate and render the rich three dimensional density and flavor of the world. All things being different, we do not claim more explanatory power for our actor-network theory. It creates an intellectual and empirical space in which a humble narratives could welcome, accommodate and render the multidimensional world of scientific and technical practice divided among at least four disciplines. Its rigidity is what allows so much flexibility. Its emptiness is its force. If a good picture cannot be confused with the perspectival grid, a good narrative should not be confused with the actor-network framework. Nevertheless, the picture as well as the narrative are allowed by these infratheories. Without this, we claim, science studies does not exist as an integrated field, only as a loosely connected aggregation of feudal domains created by contingent circumstances for other purposes.

One of the many difficulties of our theory is that it requires to embrace a generalised principle of symmetry the consequence of which is to consider associations of humans and non-humans instead of a knowing subject confronted to objects. Non-humans are requested to play a role in human interactions but this role is so different from what was expected from them in the four divided disciplines of science studies that it raises many questions in philosophy, history, social theory and anthropology. It thus offers an ideal focus to test whether or not our “backdoor strategy” may succeed in creating a core discipline of science studies.

In philosophy, it is the realist-antirealist debate that we reopen afresh. Yes, non humans are necessary to understand how controversies settle, but no, they do not look like the estranged, ahistorical, asocial characters that the realists like to oppose to their adversaries. In history, the question is to decide whether only humans have a history or if we should share historicity with things, and if so, does this modify the passage of time and the ontological presuppositions of historians? In sociology, the problem is to rearticulate social theory so as to include the non-human characters that have been excluded for so long from social relations. Yes they are social actors, but no, they do not look like the social characters that social theorists like to grant humans. In anthropology, the crucial difficulty comes from extending to our modern world the interpretive resources ethnographers are so good at using when studying premodern cultures. If the non-western cultures redesign non-human nature together with their societies, do the westerners do the same? But if this is the case then what do the words “nature” and “culture” mean? The notion of a symmetric anthropology is as problematic, as that of a new realist philosophy of science, or that of a history of things, or, while we are at it, of a social theory of non-humans! A simple methodological requirement -generalized symmetry- has opened a can of worms many would like to close. But this can is similar to Pandora’s box. Hope can be fetched in it only once all the ills have flown out of it...

## The heresy of hylozoism

I will begin this search for hope by addressing one set of objections made by Simon Schaffer to my symmetric<sup>13</sup> treatment of Pasteur and his microbes {Schaffer, 1991 #1332}{Latour, 1988 #5}. “Latour systematically understates the work of experiment. Experimental labour is neglected in *Les Microbes* because the book's narrative is marked by the heresy of hylozoism, an attribution of purpose, will and life to inanimate matter, and of human interests to the non humans” (my underline). Under the sin of hylozoism, Schaffer in fact accuses me of two different heresies. The first one is the lack of interpretative flexibility granted to nonhumans due to the absence of treatment of laboratory life practice. When I bring the nonhumans in Pasteur's company so as to close a controversy, these actants are, according to Schaffer, too faithful and well aligned to be believed, or even to be treated as *bona fide* science study resources. I would have forgotten the hard negotiation work of making allies faithful. “Latour is profoundly asymmetric as between the Pastorians and their opponents: Koch, Pouchet and the rest.”(...) “If these other voices were allowed to speak, then Latour could not so easily claim that the microbes obeyed Pasteur because he uniquely provided them with a good home. By suppressing the controversies which surrounded Pastorism, Latour is able to use 'the microbes' as wilful actors. Instead of symmetry, he tries hylozoism.” And Schaffer retorts: “Hylozoism stifles an account of laboratory life.” I could excuse myself by arguing that having already done an account of another “laboratory life” and knowing what to expect from it I did not have to insist again on interpretive flexibility. But I would not try to evade guilt by appealing to a long virtuous life, and I would plead guilty of this first heresy against the science study central dogma. Yes, I did not insist on the difficult negotiations going on in the lab. In part because of the voluntary limits on my sources, but above all because I wanted to explore another phenomenon than the by now well known “trouble with experiments”. I wanted to follow the association of human and non humans in one single narrative in order to reconstitute the very notion of a social context. In the present paper, I will make amend for this sin and will revisit the Pasteur-Pouchet debate reconciling laboratory life accounts with “hylozoism” and thus appeasing Schaffer's first indignation.

His accusation, however is hiding another one which I do not only proudly accept but which I am going to turn into an orthodoxy -to keep inside Schaffer's inquisitorial vocabulary- and compared to which he will be shown to be heresiarc and relapse! Summarizing the drawn out experimental dispute between Pasteur and Pouchet -more of it will be shown later-, our inquisitor makes a remarkable slip: “Hylozoism directs our attention towards the items whose action is in dispute. It therefore disables understanding (...) It was not the bacilli which decided to back Pasteur, because he never staged trials where they were given that chance, and they would likely have betrayed him if he had. Yet he won, and it was, as ever, his human colleagues who were crucial” (my underline). This little “as ever” is most revealing because it is the shibboleth of social constructivism (see {Collins, 1992 #1046} for another voluntary slip). Of course, social constructivists unproblematically argue, bacilli do not count. They are too flexible, too underdetermined to stabilize a debate. Bacilli simply offer a plastic and pliable backdrop for colleagues to agree or disagree among themselves about them. An interpretation that would bring the bacilli back would bring us back to the Dark Ages of realism, scientism and whiggishness. In the eye of social constructivists it would exactly be what Schaffer says, a heresy, a sin.

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<sup>13</sup> By symmetry I do not mean only Bloor's principle of symmetry -explaining truth and error by refusing to appeal to the state of nature and by using different resources for validated knowledge and for what is parascientific- but its implementation in Callon's generalized principle of symmetry -explaining nature and society in the same terms without alternating between realism and constructivism. On this question see {Callon, 1986 #1033} and in general on the debate consult the remarkable map provided in {Shapin, 1991 #1662}.

If it is not the bacillus but, “as ever”, human colleagues who come to agree among themselves about the bacilli, then through what force do they finally settle their debates? Society is the convenient answer of social constructivists. It is either that or realism. I proposed another way but Schaffer brands it with the terrible name of a 17th century religious strife. “But a hylozoist has no chance of explaining this work, since he will ignore the troubles of replication, and will always credit what the actors worked hard to discredit. In contrast, the social historians who have studied the episode help themselves to the forces of social order of French culture and to that social order of the rival labs. They do not as Latour alleges, rely on a feeble list of extrinsic “social factors”. It is they, not the analyst who anthropomorphises non human actors, who successfully “follow scientists through societies””. No dispute could be more clearly stated. The beauty of the Pasteur-Pouchet controversy is duplicated by the crisp clarity of my disagreement with Schaffer -and I will show later that they resemble one another in content as well. Either we have to bring the bacillus in, and the explanation through the social order is ill conceived, or the bacillus is so underdetermined that it is necessary for social historians “to help themselves to the forces of social order” in order to carry the day. Who follows scientists better and farther? Who “disable understanding”? The social historian or the “hylozoist”?

I want to show that the latter position is unescapable, although the word hylozoism is no more to my liking than the word “impressionists” to the taste of the first painters who escaped from the tyranny of perspectival space. I agree that having not insisted on interpretive flexibility in my first try I have weakened my case and made it liable to the first accusation. But to avoid hylozoism Schaffer is obliged to embrace a version of social constructivism that is totally flawed and absolutely unable to do the job of following scientists around. By rejecting the generalized symmetry -because of one empirical decision I acknowledge and will now correct- he too is throwing the baby with the Bath water {Callon, 1992 #1037}!

## A “matter” of life and death

Social constructivists make four major mistakes when they engage in this debate about hylozoism. First, their tug-of-war reaction against realism and empiricism is so violent that they conclude that sociologists should be forever forbidden to talk about the force of non-humans in settling scientific controversies. Realism is so implausible that they are bound to make an equally implausible claim to counteract it. Never do they imagine that it might be possible to grant non humans other qualities than those few that realists have for ages endowed them with. Second, since they have deprived scientists of non-humans to settle controversies they have to embrace a definition of social order to balance their account that has exactly the same characteristics and function as the “things” in the realist stories. Social order is the mirror image of the order of things and I will show later in the paper that they are one and the same. They never imagine that society might have many other definitions than that of conveniently coming at the end to save social historians from the underdetermination quandary, like the cavalry in western movies.

I have treated these two mistakes at length elsewhere {Latour, 1987 #580} {Latour, 1989 #1156} {Latour, 1990 #1160} {Latour, 1992 #1164} and want to concentrate here on two other more damning ones. Social historians suppose that they know the shape of humans well enough to detect when a human characteristics is unduly projected unto a mere object. It is this pretence that, in my view, “disables understanding” since it makes the whole of scientific practice totally obscure as I will illustrate on Pasteur’s case. But this third mistake is compounded by a fourth: interpretive flexibility is limited for them to the representation of non-human actors, and never extended to the ontological nature of those actants. We the humans dispute about the thing, but the thing in itself does not waver. Deep at heart, those brave social constructivists remain more scientific than most scientists -and this is why they relish so much the adjective “naturalistic”. Their objection to the scientific ethos only deals with epistemology -what settles our

representation of nature- never with ontology -what the actants are in themselves. They remain deeply anthropo- and socio-centric. I want to show how “hylozoism” extend the notion of negotiations and history to the very properties of non-humans and allow us to speak, without breaching science studies dogmas, about what things in themselves really are, thus caring at once to the realists’ worries and explaining what social order consists of. Anthropomorphism would be a small price to pay for escaping anthropocentrism, but, as we will discover, anthropomorphism is rather an understatement compared with what generalized symmetry will lead us to.

The reason why Pasteur’s definition of ferments -against Liebig chemical theory- and of homogeny -against Pouchet’s heterogeny- offers such a good case to test those arguments, is that he is himself, through his laboratory practice, engaged with the same problem of defining the real nature of those entities. It is not me, the analyst, who would project will and force over non-humans, it is Pasteur who is yet uncertain whether those “x” which are acting through trials in his laboratory are alive, chemical, spontaneous, masterable, or mere figments of his imagination. All other things being unequal he and I have the same problem: replacing the essentialist definition of non-human beings by an existentialist definition that allows us to reshuffle properties around.

To first settle my discussion with Schaffer I will use only one example, the famous Memoir on lactic acid yeast out of which Conant made one of his famed Harvard case study {Conant, 1957 #87}<sup>14</sup>. I will use it not only because it is already partially translated but also because, in the opinion of most historians, it might be Pasteur’s most single important paper<sup>15</sup>. But I have another reason to like it. In this extraordinary piece, Pasteur himself treats the four major points of contention that are the focus of this present discussion.

a) Ontology: What is the ontology that will allow us to move from one entity to a new one, in the present case from a chemical world to a biochemical world and through which transitions?

b) Epistemology: When we attribute activity to a new entity who is doing the main work, is it the scientist equipped with his own prejudices or is it the new entity itself?

c) Laboratory studies: How to understand the role of laboratory experiments in mediating between these two positions: an active scientist staging infinitely pliable trials, and an active entity forcing into assent an infinitely plastic scientist?

d) Anthropology: What is the origin of the mediation that allow properties to cross boundaries between human and non-humans, mediation that in turn could explain the essential tension of the experimental setting?

A little semiotic analysis<sup>16</sup> of the Memoir will help us scrutinizing Pasteur’s own answer and testing them against Schaffer’s accusation and my “heresies”. I am aware that Schaffer will

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<sup>14</sup> I have expanded and revised in several points the translation to render it closer to the French text.

<sup>15</sup> {GEISON, 1974 #95} comments: “With two striking exceptions this memoir contains the central theoretical and methodological features of all of Pasteur’s work on fermentation -the biological conception of fermentation as the result of the activity of living microorganisms; the view that the substances in the fermenting medium serve as food for the causative microorganism and must therefore be appropriate to its nutritional requirements; the notion of specificity, according to which each fermentation can be traced to a specific microorganism; the recognition that particular chemical features of the medium can promote or impede the development of any one microorganism in it; the notion of competition among different microorganisms for the aliment contained in the media.; the assumption that air might be the source of the microorganisms that appear in fermentation; and the technique of directly and actively sowing the microorganism presumed responsible for a given fermentation in order to isolate and purify it. The two missing features, which soon completed Pasteur’s basic conception, were the techniques of cultivating microorganisms (and thereby producing fermentation) in a medium free of organic nitrogen and his notion of fermentation as “life without air”. p.362)

<sup>16</sup> Semiotics and ethnomethodology have the same basic tenet as actor network theory: the actor themselves make their own metalanguage and the analyst’s jargon as no other aim except deploying the world built by the actor, or the text, or the setting. The reflex is the same in the three research programs: whatever question we might

insist on more than a text and more than one text to be convinced, but my argument is an *a fortiori* one. If in this one Memoir are already deployed so many various answers to the questions he raises, then if more documents and archives were added, we would need a still more open relativistic space to render them. No commonsense solutions will help us -although I hope to show in the end that hylozoism could become a commonsense solution. In another section of the paper I will show how to move from this text to the other documentary evidences dearer to the historians' heart.

### Structure of the text or how the last will become the first

This paper tells a drama. At the beginning of the paper, lactic acid yeast is nothing but an almost invisible by-product of purely chemical fermentation mechanism, or even worse, something which would hinder and spoil the fermentation. At the end of the paper it is a full blown new entity, integrated into a class of similar phenomena, which is the sole cause of fermentation.

§7 “When examined under the microscope, when one is not forewarned (*prévenu*), it is hardly possible to distinguish it from casein, disaggregated gluten, etc.; in such a way that nothing indicates that it is a special (*special* separate in Conant) material, or that it was produced during the fermentation. Its apparent weight always remain very little as compared to that of the nitrogenous material originally necessary for the carrying out of the process. Finally, very often it is so mixed with the mass of casein and chalk that there would be no reason to suspect its existence. It is it nevertheless that plays the principal role.”

Similarly, at the beginning of the paper, Pasteur's opinion<sup>17</sup> is nothing against Liebig's and Berzelius's powerful theories. At the end of the paper, Pasteur's triumphs of his enemies and his view wins against all odds, the chemical account of the fermentation being soon defeated.

§6 “The facts [that makes the cause of lactic acid fermentation so obscure] then seem very favorable to the ideas of Liebig or to those of Berzelius. (...) These opinions gain more credit daily. (...) These works all agree in rejecting the idea of some sort of influence from organization and life as a cause of the phenomena that we are considering. I have been led to and entirely different point of view.”

At the beginning of the paper, we live in a world where relations between organic matter and ferments is that of contact and decay, at the end we might to live in a world where a ferment is as lively as a specific life form, so much so that it now feeds on the organic material which has become food for it instead of being its cause.

§6 “In the eyes of the [Liebig] a ferment is an excessively alterable substance that decomposes itself and thereby excites fermentation in consequence of its alteration by disrupting through communication and by disassembling the molecular group of the fermentable matter. According to Liebig, such is the primary cause of all fermentations and the origin of most contagious diseases. Berzelius believes that the chemical act of fermentation is to be referred to the action of contact.”

§22 [Everyone] “will recognize with me that fermentation appears to be correlative to live and to the organization of globules, and not to their death and putrefaction, no more than fermentation is a

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have about a subject, the subject itself has reconstituted it in a more interesting way. The metalanguage is in the actor's own hand. The analyst only possesses an infra language. What is forbidden in the three programs is to read through a setting a meaning that would simply be conveyed or transported by it. There is no intermediaries, only mediators. Semiotics is, so to speak, ethnomethodology of a text and ethnomethodology semiotics of interactions.

<sup>17</sup> To simplify I will use the word Pasteur to describe the author of the text. This is obviously a crime against semiotics since the enunciator is represented through many different guises in this text all of them very interesting and none of them are anthropomorphised and psychologised. See more of that later.

phenomenon due to contact in which the transformation of sugar would take place in the presence of the ferment without giving up anything to it or taking anything from it.”

More importantly, at the beginning of the paper, fermentation is an haphazard phenomenon which is unknown, uncertain, and understandable. At the end, it can be produced almost at will and new gestures are invented, sowing or sprinkling yeasts, cultivating it in a medium as one would do with plants in a garden, and varying its condition of existence, its environment.

§9 “In this experiment the yeast extract can be replaced by an extract of any nitrogenous plastic substance, fresh or decomposed, as the case may be. This limpid liquid, containing a nitrogenous substance in solution, is nothing but food, and in this respect its origin is of little importance provided it is of such a nature as to facilitate the development of the organized body (*corps organisé*) that produces itself and is gradually deposited.

§ 16 “Whenever an albuminous liquid of a suitable nature contains a substance such as sugar, capable of undergoing diverse chemical transformations dependent upon the nature of such and such a ferment, the germs of these ferments all tend to propagate at the same time, and usually they develop simultaneously, unless one of the ferments invades the medium more rapidly than the others. It is precisely this last circumstance that one determines when one use this method of sowing an organism that is already formed and ready to reproduce.”

When the non-humans are mobilized in Pasteur’s text what sort of properties do they have? Are they stable and matter-of-factual? Do they resemble the things alluded to in the realists’ accounts of science? Do they irrupt in the text as those dumb things against which social constructivists have fought so much and declared a heresy to ever use as an explanation? Not a bit. To be sure, a few are imported in the text as so many uncontroversial black boxes composing the background -the microscope, the definition of sugar, of alkalinity, etc.- but many others are foregrounded and used as grey boxes with many qualifications - “the law of hemihedral correlation”, Liebig’s theory, the link between optical activity and life, etc. Still others, the center of the attention are completely transformed in the course of the story -brewer’s yeast is now made one instance of a whole class of phenomena; air is now separated into different functions, its chemical composition on the one hand and its action as carrier of ferments on the other; the organic broth which was before the cause of the ferment through degradation and contact is now made the food of organisms and becomes a medium of culture. Non-humans change in the course of the text and are, at least from some of them, reshaped from top to bottom from one paragraph to the next.

### **Pasteur’s ontology: the main circulating object and its transformations**

This is what happen to the main character of the drama, this actant *x* that will soon be named lactic acid fermentation yeast? Is it a matter-of-fact, unfairly tipping the balance while humans go on discussing among themselves about it? No, it is not yet a matter of fact. For now, it is a circulating object inside the text undergoing all sort of trials and submitted to an extraordinary series of transformations<sup>18</sup>. At first its very existence is denied.

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<sup>18</sup> It is the power of semiotics to allow one to follow non-human characters in a scientific text with the same sort of precision as a human character in a literary one. The work of attributing properties and shaping identity and insuring stability in a story is the same in both cases {Greimas, 1976 #402} {Greimas, 1982 #1301}. Of course the ontology of semiotics is deeply flawed {Pavel, 1986 #752} but it remains without contender when non human plasticity and activity is to be explored. I used it, as an amateur I admit, and then add to it an ontology and a social theory more in keeping with my goals {Latour, 1991 #1523} (English translation to appear at Harvard University Press).

§4 “Until now minute researches have been unable to discover the development of organized beings. Observers who have recognized some of those beings have at the same time established that they were accidental and spoiled the process.”

Then, the main experiment that Pasteur has staged -in the text as well as in his laboratory- allows “a forewarned observer” to detect it. But this object *x* is stripped of all its essentialist qualities and redistributed among elementary sense data.

§7 “If one examines carefully an ordinary lactic fermentation, there are cases where one can find, on top of the deposit of the chalk and of nitrogenous material, spots of a grey substance which sometimes form a layer (*formant quelquefois zone*) on the surface of the deposit. At other times, this substance is found adhering to the upper sides of the vessel, where it has been carried by the movement of the gases.”

§10 “When it solidifies (*prise en masse*) it looks exactly like ordinary pressed or drained yeast. It is slightly viscous, and gray in color. Under the microscope, it appears to be formed of little globules or very short segmented filaments, isolated or in clusters, which form irregular flakes resembling those of certain amorphous precipitates.”

It is not an object yet, but a cloud of floating perceptions not yet the predicates of a coherent substance. In Pasteur’s philosophy of science the phenomena precede what they are the phenomena of. Existence precedes essence. To grant it an essence, to turn it into an actor something else is necessary, the laboratory series of trials through which the object *x* proves its mettle, so to speak. Pasteur makes it what I have called elsewhere “a name of action”: we do not know what it is, but we know what it does through the trials staged in the lab {Latour, 1987 #580}. This is pragmatism but extended to non-human actors. Or to allude to yet another philosophical movement, series of performances precedes the definition of the competence that will then later be made the sole cause of those very performances.

§8 “About fifty to one hundred grams of sugar are then dissolved in each liter, some chalk is added, and a trace of the gray material I have just mentioned from a good, ordinary lactic fermentation is sprinkled in (...) On the very next day a lively and regular fermentation is manifest. The liquid, originally very limpid, becomes turbid; little by little the chalk disappears, while at the same time a deposit is formed that grows continuously and progressively with the solution of the chalk. The gas that is evolved is pure carbonic acid, or a mixture in variable proportions of carbonic acid and hydrogen. After the chalk has disappeared, if the liquid is evaporated, an abundant crystallization of lactate of lime forms overnight, and the mother liquor contains variable quantities of the butyrate of this base. If the proportions of chalk and sugar are correct, the lactate crystallizes in a voluminous mass right in the liquid during the course of the operation. Sometimes the liquid becomes very viscous. In a word, we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists.”

We do not know yet what it is, but we know that it can be sprinkled<sup>19</sup>, that it triggers fermentation, that it renders a liquid turbid, that it makes the chalk disappear, that it forms deposit, that it generates gas, that it forms crystals, that it becomes viscous. It is a list of records into the laboratory notebook. *Membra disjecta* that do not pertain to one entity yet. Properties looking for what they are the property of. At this stage the entity is so fragile, its envelop so undetermined, that Pasteur notes with surprise its ability to travel from one end of the lab to the other.

§10-It can be collected and transported for great distances without losing its activity, which is weakened only when the material is dried or when it is boiled in water. Very little of this yeast is

<sup>19</sup> See Hacking’s definition of reality in experiment, if it can be sprayed it exist {Hacking, 1983 #1459}.

necessary to transform a considerable weight of sugar. These fermentations should preferably be carried on so that the material is protected from the air, so that they will not be hindered by vegetation of foreign infusoria.

May be shaking the flask will make the phenomenon disappear, may be carrying it along? Before the first drawing of the envelop is underlined by an ontological property, Pasteur has to add precautions that he will soon find useless. Not knowing what it is he has to trespass the dotted boundaries so as to give it a shape. But how can he move higher in ontological status, how could he transform this fragile boundary into an envelop, how to move from this “name of action” to a “name of thing”? If it acts so much the entity  $x$  has to be an actor? Not necessarily. Something more is needed to turn this actantial role into a full blown actor to which will be attributed the origin of those actions; another act is necessary to conjure up the substrate of those predicates, the competence of which these laboratory trials simply express the performances. In the main part of the paper, Pasteur does not hesitate. He uses everything at hand to stabilize the substrate of this entity and grants it an activity similar to that of brewer’s yeast, and similar to a plant in a plot of land. Borrowing these powerful metaphors allows him to use the well known ontological status of domestication and culture of plants in order to give shape to his aspiring entity.

§11- “Here we find all the general characteristics of brewer’s yeast, and these substances probably have organic structures that, in a natural classification, place them in neighboring species or in two connected families.

§13- “There is another characteristic that permits one to compare this new ferment with brewer’s yeast: if brewer’s yeast instead of the lactic ferment is sown in limpid, sugared, albuminous liquid, brewer’s yeast will develop, and with it, alcoholic fermentation, even though the other conditions of the operation remain unchanged. One should not conclude from this that the chemical composition of the two yeasts is identical any more than that the chemical composition of two plants is the same because they grew in the same soil.”

What was a non-entity in §7, becomes so well established in §11 that it has a name and a place in the most precise and most venerable of all branches of natural history, taxonomy. No sooner has Pasteur thus shifted the origin of all the actions to the yeast that becomes a full blown independent entity, that he uses it as a stabilised element to redefine all the former practices. We did not know that we were doing before, but now we know.

§12- “All the chemists will be surprised at the rapidity and regularity of lactic fermentation under the conditions that I have specified, that is, when the lactic ferment develops alone; it is often more rapid than the alcoholic fermentation of the same amount of material. Lactic fermentation as it is ordinary carried out takes much longer. This can easily be understood. The gluten, the casein, the fibrin, the membranes, the tissues that are used contain an enormous amount of useless matter. More often than not these become a nutrient for the lactic ferment only after putrefaction - alteration by contact with plant or animalcules- that has rendered the elements soluble and assimilable.”

A slow and uncertain practice the explanation of which was obscure, becomes a quick and comprehensible mastered set of new methods: the cultivation of microorganisms in a medium which provides food for the ferment, food that itself may be varied so as to vary the adaptation to an environment of various ferments in competition. The cause of a useless by-product is transformed into the food of its consequence!

Going further and further, Pasteur turns this newly shaped entity into one “singular case” inside a class of phenomena, the fermentations the general “circumstances” of which may be now defined.

17- “One of the essential conditions for good fermentations is the purity of the ferment, its homogeneity, its free development without any hindrance and with the help of a nutrient well adapted to its individual nature. In this respect, it is important to realize that the circumstances of neutrality, alkalinity, of acidity, or of the chemical composition of the liquids play an important part into in the predominant growth of such and such a ferment, because the life of each does not adapt itself to the same degree to different states of the environment.”

This mystery of mystery -how can a new entity emerge out of the old one- is treated by Pasteur with much details, going from a non existing entity to a class through the stage of being made of floating sense data, taken as a name of action, and then turned into a plant-like living and organised being.

### **Pasteurs’ solution to the conflict between constructivism and realism: the second drama**

Still, there is a gap in this genealogy or this pragmatogony. How to go from the barely visible gray matter that sometimes appear on the top of the vessel to the plant endowed with feeding requirements and rather particular tastes. How to make this crucial step? Who is doing the attribution of action and the endowment of properties? Is Pasteur not open to Schaffer’s criticism that he is pushing the thing so as to grant it an ontological status higher than what can be deduced from experiments? Is he not doing a little sleight of hand through which the whole of human activity will leak back in? Pasteur “confesses” it very explicitly in the very last paragraph of the paper. He is doing the action, he has prejudices, he is filling the gap between underdetermined facts and what should be visible.

22- “All through this memoir, I have reasoned on the basis of the hypothesis that the new yeast is organized, that it is a living organism, and that its chemical action on sugar corresponds to its development and organization. If someone were to tell me that in these conclusions I am going beyond that which the facts prove, I would answer that it is quite true, in the sense that the stand I am taking is in a framework of ideas (*un ordre d’idées*) that in rigorous terms cannot be irrefutably demonstrated. Here is the way I see it. Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be inclined to assign their primary cause to a type of reaction consistent with the general results of his own research. It is the logical course of the human mind in all controversial questions.”

Not only does Pasteur develop a whole ontology in order to follow the transformation of a non-entity into an entity, but he also has a philosophy of science and a pretty sophisticated one at that. As most French scientists he is a constructivist, for him facts always need to be framed and built up by a theory<sup>20</sup>. The origin of this inevitable “*ordre d’idées*” is to be found in disciplinary loyalties (“a chemist”), themselves tied to past investment (“consistent with the general results of his own research”). This very inertia is rooted by Pasteur in culture and history (“his own research”) as well as in nature (“instinct”, “the logical course of the human mind”). This is a fascinating account of the origin of a prejudice, all the more so because social historians often claim to criticize Pasteur because he is imbued with prejudice and jump beyond

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<sup>20</sup> Many misunderstandings in science studies may be linked to this feature so brilliantly shown by Duhem and so rapidly forgotten: the British are for ever fighting for or against empiricism from Hume to, say, Collins. On the Continent, empiricism has always been a dead horse and the underdeterminacy of facts is the rule. The gap is filled by theory and of course not by society or consensus. But the outcome is this: the fight against empiricism has used up all the forces of the science students. Continental scholars arrive to the task fresh as a rose and since they never had to burn out their forces into this dispute they can concentrate on other more interesting issues!

the facts<sup>21</sup>. But this is what Pasteur himself recognizes over and over again. So the metalinguistic resource that historians apply is actually handed to them by their subject matter! Far from creating a useful distance between Pasteur and themselves, they select only one part of his rich repertoire and happily ignore the rest pretending to force upon him a definition of influence and history or politics which is much poorer and less enlightening than Pasteur's own, as I will show in another section.

Does this confessed prejudice weaken Pasteur's claim in his own eye? Not a bit. The very next sentence introduces another epistemology, a much more classical one in which facts may be unambiguously evaluated by impartial observers:

§22- "And it is, in my opinion, at this point in the development of my knowledge of the subject, that whoever judges impartially the results of this work and that which I shall shortly publish will recognize with me that fermentation appears to be correlative to life and to the organization of globules, and not to their death and putrefaction."

Whereas in the sentence before the logical course of human mind precluded "impartial judgement", especially in "controversial questions" which cannot be "irrefutably demonstrated", it is suddenly possible for the same Pasteur to convince anyone who is impartial. Two entirely unrelated epistemologies are juxtaposed. Why? Is there a contradiction? Or are we unable to reconcile constructivism with empiricism? Facts need a theory to be made visible and this theory is rooted in the former history of the research program -it is "path dependent" as economists would say- but facts may be judged without influence of earlier history. Whose contradiction is this? Pasteur's or ours?

As long as we find contradictions in a text or in a setting it simply means that we are not relativist enough, that we are trying to gloss over an actor's meaning and impose our categories instead of deploying hers. In order to grasp how Pasteur without any sign of being paradoxical may go from one epistemology to its polar opposite we have to understand how he himself distributes activity between he, the experimenter, and the would-be tentative ferment, and also what is the origin of this deep seated commitment that instinctively leads to imagine for the object  $x$  a "type of reaction consistent with the general results of his own research". By following those two answers we will be led to Pasteur's own definition of Schaffer's question and thus to my own answer to them.

The text is thus structured around two combined drama. The first one, as I briefly summarized, modifies the status of a non-human and of a human. It converts a non-entity, the Cinderella of chemical theory, into a glorious and heroic character. In parallel, Pasteur's opinion, the Charming Prince, triumphs against all odds and reverse Liebig's theory. "The stone which the builders rejected has become the chief corner-stone" (cite Gospel). But there is a second drama, a reflexive one, that appears only at the end: who is constructing the facts, who is leading the story, who is pulling the strings? The scientist's prejudice or the non-humans? To the ontological drama is added an epistemological one.

### **Pasteur's own version of laboratory studies: the trouble with experiments**

The beauty of this Memoir is to offer a mediation between those two questions, a mediation which is often forgotten or obscured in philosophy of science but not in science studies, that of experiment and instrument and the question of the interpretive flexibility of facts and artefacts. For Pasteur it is in the experimental details that we can find the solution to the aporia above.

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<sup>21</sup> Such is the constant historiographic line of attack of {GEISON, 1974 #95}{Farley, 1974 #89}{Geison, 1988 #88} that is refuted, ironically enough, by others {Roll-Hansen, 1979 #7} {Temple, 1986 #91} who claim that there is no circle in Pasteur's reasoning, although Pasteur freely recognizes it...

What is an experiment? It is an action performed by the scientist so that the non-human be made to appear of its own. Its a very special form of constructivism as Shapin and Schaffer have so beautifully shown since it overcomes its own construction {Shapin, 1985 #869}. The artificiality of the laboratory does not run against its validity and truth, its obvious immanence is actually the source of its downright transcendence. How could this apparent miracle be obtained? Through a very simple set up that has baffled observers for very long and that Pasteur beautifully illustrates. The experiment creates two narrative planes: one in which the narrator is active, and the second in which the action is delegated to another character, a non-human one.

An experiment shifts out<sup>22</sup> action from one frame of reference to another. Who is acting in this experiment? Pasteur and his yeast. More exactly, Pasteur acts so that the yeast acts alone. We understand why it is difficult for Pasteur to chose between a constructivist epistemology and a realist one. Pasteur creates a scene in which he does not have to create anything. He develops gestures, glasswares, protocols, so that the entity, once shifted out, becomes automatic and autonomous. According to the ways in which those two contradictory features will be stressed the same text becomes constructivist or realist. Am I, Pasteur, making this entity up because I am projecting on it my prejudices, or am I being made up and forced to behave that way because of its properties? Am I, the analyst of Pasteur, explaining the closure of the controversy by appealing “as ever” to his human interests, or do I have to add to the balance the active role of those entities he did so much to shape? These questions are not philosophical problems confined into the pages of *Social Studies of Science*. or *Isis* They are the very questions of all scientific practices taken over and over by scientific papers and resolved much too fast, in my view, by arguments such as Schaffer’s.

The experimental scenography in this Memoir is extremely varied to follow all the subtleties of the variable ontology deployed in the text. Again, the question of deciding if experiments are uncertain or stable is not one of those hair splitting arguments sociologists of science like to make, but is tackled directly by all scientific papers. In the same Memoir, some experiments will be be backgrounded and blackboxed, while others will be made the center of the attention and will be made to vary. At first, the practice of doing science is alluded only through very stylized experiments which are backgrounded<sup>23</sup>. Then, human agency is reintroduced in a recipe-like procedure to describe lactic acid fermentation. But at his stage there is no “trouble with experiments”. Fermentation of lactic acid is a well known procedure which Pasteur imports as such<sup>24</sup>. “

§4- “Lactic acid was discovered<sup>25</sup> by Sheele in 1780 in soured whey. His procedure for removing it from the whey is still today the best one can follow. [text of the note] First he reduced the whey to an eight of its volume by evaporation. He filtered it and saturated it with lime to precipitate the phosphate of lime. The liquid was then filtered and diluted with three times its weight of water;

<sup>22</sup> Shifting out is a semiotic expression that describes the possibility of displacing action into another time, another space or another actant. On its use in scientific text see {Latour, 1988 #1151}. Shifting in means closing the first shift by reverting to the original frame. I introduced shifting down to express the delegation to technical objects {Latour, 1992 #1324}.

<sup>23</sup> For instance in a sentence like this one §2- “for every time that one tries to find the optical activity of a substance in its derivatives, it promptly disappears” there is nothing more than the vaguest allusion to an experimental setting and to an effort being made in order to recvoer an activity. The instrument is unknown.

<sup>24</sup> This is one of the many worries I have with the antiempiricism move of my critics in science studies. They are always extremely ingenious to show why the experiments is uncertain, or underdetermined, but they are never as good to show why some of them become standardized, routinized, simplified, and stylized. Again, not having to fight against empiricism, I find much more interesting to record the whole gamut of positions taken by scientists on the difficulties of turning an expriment into a stable procedure. Only one of them consists in trouble shooting the defects of one by importing others.

<sup>25</sup> Note that on the imported procedure Pasteur is not a constructivist and use the notion of “discovery” without any qualification, but Liebig’s theories are on the contrary negatively modalized. So a text deploys in the same space all the gamut of philosophies of science. It is the same with philosophy of experiments.

into this he poured oxalic acid drop by drop to precipitate all the lime. He evaporated the liquid to the consistency of honey. The thickened acid was redissolved in rectified alcohol, which eliminated the milk sugar and many other materials. The alcohol was removed by distillation.”

Firmly grounded in practice but completely blackboxed, the experimental procedure defines the base line -lactic fermentation- out of which the foregrounded yeast will be made to appear. Without a stabilized recipe for lactic fermentation no yeast could start to show its mettle.

Insisting for ever on interpretive flexibility is a useless game (of chicken?) if one does not specify which part of the document one is studying, the background, the foreground, the baseline, or the main experiment. In one paper, we may go through several philosophies of experiment with Collinesque or Hacking-like moments preceded by brutal denial of the role of instrument and followed by positivists accounts. For instance, the scenography changes completely when we reach the two central paragraphs 7 and 8 in which is displayed the main experiment. Activity is back in and so are the troubles.

§8- “I extract the soluble part from brewer’s yeast, by treating the yeast for some time with fifteen times its weight of water at the temperature of boiling water. The liquid, a complex solution of albuminous and mineral material, is carefully filtered. About fifty to one hundred grams of sugar are then dissolved in each liter, some chalk is added, and a trace of the gray material I have just mentioned from a good, ordinary lactic fermentation is sprinkled in; then one raises the temperature to 30 or 35 degrees centigrade. It is also good to introduce a current of carbonic acid in order to expel the air from the flask, which is fitted with a bent exit tube immersed under water. On the very next day a lively and regular fermentation is manifest. (...) In a word, we have under our eyes a clearly characterized lactic fermentation, with all the accidents and the usual complications of this phenomenon whose external manifestations are well known to chemists.”

At the very time when the entity is at its weakest ontological status, reshuffled among disconnected sense data, the experimental chemist is in full activity extracting, treating, filtering, dissolving, adding, sprinkling, raising the temperature, introducing carbonic acid, fitting tube. But then, shifting out the attention of the reader, he says that “we have under our eyes a clearly characterized lactic fermentation”. The director withdraw from the scene, and the reader, merging her eyes with those of the stage manager, sees a fermentation that takes up independantly of any work and construction. All the many mediations have become transparent intermediaries.

Who is doing the action in the new medium of culture? Pasteur since he sprinkles, and boils, and filters, and sees. The lactic acid yeast since it grows fast, uses up its food, gains power ("very little of this yeast is necessary to transform a considerable weight of sugar") and enters into competition without other similar beings growing like plants into the same plot of land. If I ignore Pasteur’s work I fall into the pitfalls of realism out of which fifteen years of laboratory studies has extracted us. As Shapin would say “we go back to the trees our ancestors came from”. But what happen if we ignore the lactic acid delegated automated autonomous activity? We fall in the other pit, as bottomless as the first, of social constructivism, forced to ignore the role of non-humans which are the centre of attention of all the people we study, and on the staging of which Pasteur spent months of labor. To which tree are we now climbing back? We cannot even claim that in both cases it is only the author, the human author, who is doing the work since what is at stake in the text is precisely the reversal of autorship and authority: Pasteur authorizes the yeast to authorize him to speak in its name. Who is auhtoring the whole literary process is itself an open question where characters and authors are exchanging credibilities -it is only if the Academy colleagues disbelieve Pasteur that he will be made the sole and only author of a work of fiction. If the whole set up resists the Academy scrutiny then

the text itself will be in the end authorized by the yeast the behavior of which will be said to underwrite the whole text<sup>26</sup>

How could we understand the experimental staging that aimed at letting the lactic acid develop alone by itself in a pure medium of culture? Why is it so complicated to recognize that an experiment is precisely the place where this contradiction is staged and resolved? We do not have to choose between two accounts of scientific work since this very scientific work aims at building a scene in which scientists do not do any work. Pasteur is not plagued here by false consciousness, erasing the traces of his own work as he goes along, since he explicitly stages these two contradictory requirements in the last paragraph. “Yes, says he, I went well beyond the facts, I had to, but whoever judges impartially will recognize that lactic acid is correlative of life not of death.” To acknowledge his activity is not, in his view, to weaken the claim for the independence of his yeast, no more than to see the threads in a puppeteer’s hands weaken the credibility of the story happening to the puppets “freely” acting in the other plane of reference.<sup>27</sup> As long as we have not understood why what appear to us as a contradiction is not one for Pasteur we do not learn from those we study -we simply impose our philosophical categories onto their work.

### **Pasteur’s anthropology of science: anthropomorphism and microbiomorphism**

But we have not yet moved much beyond the epistemological contradiction. We have simply, it seems, compounded it by the miracle of experimental settings. Pasteur feels authorized to go beyond the facts, because, in the experimental scenography, he let the yeast develop by sowing it in a pure form. Instead of one contradiction -constructivism versus realism- we have now a second one -plane of active scientist versus plane of autonomous non-humans-, the latter underwriting the first one but without resolving it. We have to recognize a gap in the reasoning since Pasteur himself recognizes there is one. Let us look more closely at the exact wording of this crucial paragraph:

§22“All through this memoir, I have reasoned on the basis of the hypothesis that the new yeast is organized, that it is a living organism, and that its chemical action on sugar corresponds to its development and organization.”

It is impossible to let the experiments show the yeast acting without pushing the yeast a bit and adding to it the property of being a living organism. But why is Pasteur so sure that there is no damning contradiction between his prejudices that force him to determine the underdetermined facts and the impartial judgement of his Academy colleagues (“whoever judges impartially the results of this work and that which I shall shortly publish will recognize with me”)? Why does he know that he, the puppeteer, can withstand the trial by letting his puppets alone undergo the experiment? Let us not forget that the transition between the two contradictory epistemologies resides in the sentence I quoted above:

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<sup>26</sup> This is why it is so difficult to see scientific texts as text. They appear such only in very rare circumstances -when they have been transformed into fiction or when they have aged enough for their documentary style to become a style. In the other cases they appear as so many documents and reports.

<sup>27</sup> Already in Laboratory Life we had shown how the very construction of facts erased all traces of its construction. But we interpreted this reversal in a more classical marxism fetishism theory, as if it was a bad thing for a fact to lose its traces, as if it was a case of false consciousness. The power of Shapin and Schaffer’s interpretation comes from showing  $\Sigma$  that for Boyle constructivism is a positive feature that does not undermine the final truth value of facts but, on the contrary establishes it. I offer here still a further elaboration on this dual feature of scientific constructivism.

§22- “Whenever a chemist makes a study of these mysterious phenomena and has the good fortune to bring about an important development, he will instinctively be inclined to assign their primary cause to a type of reaction consistent with the general results of his own research. It is the logical course of the human mind in all controversial questions”.

The meaning of this mysterious sentence will lead us to the heart of Pasteur’s anthropology of science and might vindicate hylozoism thus solving the set of contradictions in epistemology and laboratory studies that now depend on it. This sentence is the key that open for good the enchanted realm of science studies!

How can a non-human -the yeast- become independent of the human that make it up? How can a human learn new properties -in this case biological- from a non-human that is not even visible and may not exist if chemical theory is right? We need a mediator, a translator, to transit in between the two and cross the boundaries. Who is this mediator? Someone, a chemist, who has the “good fortune” of “bringing about” an important “development” in these “mysterious phenomena”. Who is this “*passeur*”? Pasteur to be sure, the chemist, who had tried, as Geison has so beautifully shown {Geison, 1974 #95}, to cross the mysterious boundaries between dead and living matter, symmetric and asymmetric forces.

To fill in the gap between what the facts show and the “hypothesis” in term of organized life, Pasteur brings in deep seated presuppositions, so deeply rooted that he can call them an “instinct” and use it to define what it is to be a chemist rewarded by good fortune. What can be strong enough to foot the bill? Ambition? How to go from Arbois to fame in the whole world? Certainly. But something more specific is needed. There is nothing that is closest to us as our body and nothing more cherished as our skills. I think that part of the explanation of this sentence resides in Pasteur’s conviction that it is possible to exchange properties with a non-human, or as Geison says to produce life in the laboratory, to fight with the original forces in order to become another French Newton.

In a closely connected paper that appears a few months after the lactic acid one<sup>28</sup> Pasteur shows this exchange of properties in a striking manner. He announces a new method to separate racemic acid, a biological one by granting to an another object  $x$  his months of labor at sorting out with a tweezer right handed crystal from left handed crystals<sup>29</sup>. Chemistry and especially crystallography is hard work, hard active human work. Pasteur’s ability to separate under the microscope the isomeric forms is without equal, but it is tedious and slow. What happen if another agent does the same without microscope, without twizzer and fast? Pasteur grants, delegates, shifts his whole energy, his own unequalled skill to a non-human, a something-that-knows-its right-from-its-left. No wonder he believes the ferment to be strong, active, powerful, skilled -he has already exchanged part of his properties with it! Who is playing with the heresy of anthropomorphism? Pasteur, not me. Similarly, in the paper on lactic acid, who is flirting with the heresy of vitalism to Liebig’s dismay? Pasteur, not me. This might be why he is “instinctively inclined to assign their primary cause to a type of reaction consistent with the general results of his own research”, a metamorphosed Pasteur metamorphoses fermentation.

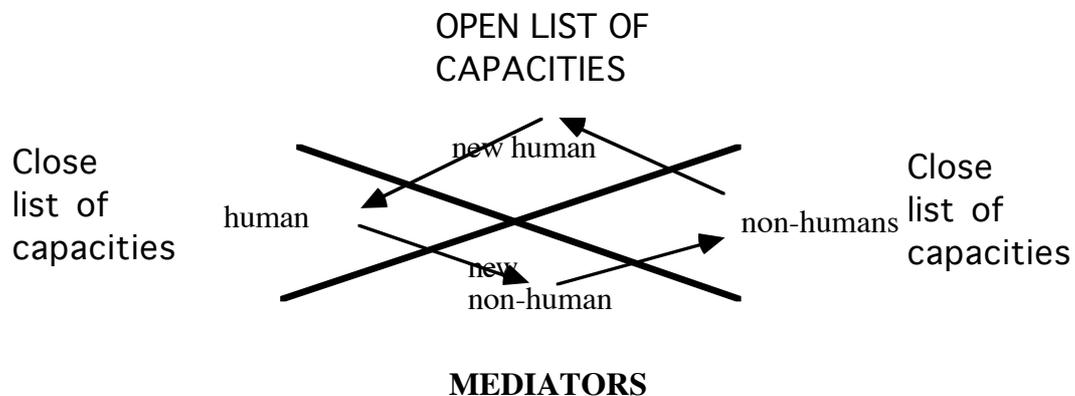
We always look at science as if this was the only place where, finally, objectivity and subjectivity were clearly separated, and distanced. But, if I am right, and if Pasteur is a good guide, a laboratory experiment is precisely the place where the distance between objects and subjects of study are minimal. Scientists have to assimilate, absorb, play, represent, translate, absorb, digest the properties of the non-humans in the name of which they speak, but those non-humans in turn are defined by clothing some of the properties of the humans that speak in their names. They are swapping properties reshuffling who and which they are. Hylozoism is an

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<sup>28</sup> {Check with Jerry the dates in the note books to see the temporal order of those two sets of experiments closely connected}

<sup>29</sup> The transition between the methods is instructive. The first one is manual, the second is chemical, the third one is biological. See...

understatement for defining this boundary zone where these transactions happens. Pasteur's shape is defined and so is that of the ferment. If we look at the two extreme definitions of human and non-humans in the diagram above, then they have stable properties and mixing them is an absurdity, an heresy, a sin, Schaffer is right -and so, incidently is Liebig who fights so fiercely against vitalism. But if we look at the middle mediation, as I have clumsily tried to do from the start of my interest in science studies, the situation is altogether different. Some of the properties of Pasteur -discrimination, hard work, speed, will to reproduce, identity, competition- are used in order to shape a new non-human, to grant it additional properties. Then, this new non-human is added to the list of what we know non-humans are able to do. Its capacities are registered as what the world is capable of doing. But how do we know what humans are able to do in the first place? How do we list the capacities that have been registered in their environment? From another movement going the opposite direction. A human is now defined by borrowing properties from the realm of already fixed non-humans. This new human endowed with new abilities -a physiology, a brain, a set of reactions, an optical activity, an instinct, - is then registered as the essence of human nature.



But who is doing the activity, an (exasperated?) Schaffer might ask. Is it not, as usual, a human? No, not necessarily, because the very question of who is doing the action is being modified here. Pasteur, a new Pasteur, bears on his shoulder a new non-human and shapes it with its own assimilated body, the hybrid thus created through this metamorphosis, will then be registered, once stabilised, as made of two parts, a new revolutionary scientist honored by the Academy because of his discoveries, and, on the other hand, a ferment discovered by Pasteur and populating the world out there. A laboratory, an experiment, is such a transaction zone, such a melting pot, such a cyborg {Haraway, 1991 #1001}, that new capacities and properties are exchanged between humans and non-humans, thus representing the modern equivalent of this anthropological swap so pervasive in "premodern" cultures <sup>30</sup>. To the metamorphosis of traditional cultures-natures we, the moderns, have added the vastly enlarged metamorphosis through which many shapes -*morphos*- are defined, that of bacilli but that of humans as well<sup>31</sup>.

If I am even remotely right, then it would be a sin not to focus attention, through whatever means, on the transaction zone where such an important swap occurs, because this is where innovation could be accounted for. It is worth being accused of hylozoism, if I am thus able to

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<sup>30</sup> It is very instructive, in that respect, to follow scientists' gestures while they speak of the brain, of galaxies, or of virus. Their body is wholly familiarized with the structure they talk about. Instead of describing they inhabit what they is supposed to be absent, reenacting it, offering another transition zone very much like hunting rituals described by anthropologists where the community assimilate the very shape of that which is far away and cannot be otherwise grasped.

<sup>31</sup> The position of the enunciator is as instructive as that of the main circulating object. There are many fragments of humans in the text but none of them look like an anthropomorphic self contained continuous individual human. It is a field of *membra disjecta* which gather some unity only at the very end and beginning of the text when defining his own research program -see the semiotic inventory.

focus the attention of much better scholars than myself, to the locus where the very definition of what is matter, life, and humanity is being reshuffled. In using against me the common sense evidence that human always do the acting, Schaffer believes he knows for ever what are the properties of humanity, society, matter, and biology. Too bad he chose Pasteur's case, since in those years in the laboratory, the very definition of what is life, chemistry, physiology, are being reconstituted. Closing the list at a time it is open diverts the attention away from the transaction zone and "disables understanding" by pointing at the two extremes -stabilised humans and stabilized non-humans. If the "human" has a place in our accounts it is certainly not one of the two poles of the diagram above, but a much stranger entity, a delegator, a non-human, a transaction zone. Commonsense humanism is not what we can bring as an off the shelf resource to study science in action.

## Does reality leak in?

If, I have claimed so many times, the essential question of science studies is the following one: how can non-humans become part of our collective life?, then hylozoism, redefined as above, could point to the entry point of non-humans into the collective and thus explain innovations. To understand why such a model is necessary we have to look at the alternative model I am fighting against and that Schaffer appears to find so palatable. I call it the "leak in" model because after having gone to one extreme in order to show that facts are indefinitely pliable they suddenly alternate to the opposite view and let non-humans leak in<sup>32</sup>. I found an excellent illustration of this model in an otherwise remarkable article by Geison and Secord. The first sentence reads:

"Most historians, philosophers, and sociologists of science no longer routinely assume that such discoveries as Pasteur was about to make can be explained by simple reference to the empirical evidence, to the "real world out there". Indeed one purpose of this essay is to suggest just how pliable the supposedly "hard" evidence of nature can be."{Geison, 1988 #88} p.30

This is the central dogma of social history and of social constructivism and squares perfectly well with Schaffer's requirement that "as ever" human colleagues settle disputes about facts - and I adhere to it to the point of making it the third rule of method {Latour, 1987 #580} chapter II. But here is the following sentence, an extraordinary one, that alternates suddenly with the other extreme, going in one long sweep, from social shaping to the crudest form of empiricism:

" Yet every once in a while we do come face-to-face with a situation that requires us to pay attention to the empirical evidence at hand. For no obvious reason to be found in his prior theoretical commitments or other concerns, Pasteur was simply unable to ignore his observation of left- and right handed crystals in the sodium-ammonium paratartrate" (id)

This is where I part company with the social constructivist because I have first embraced their first excellent rule of method and do not wish to jeopardize everything we have learned thanks to its application -see {Latour, 1987 #580} rule number four. What on earth could force two of the best social historians of science to such an implausible alternation? The necessity of explaining innovation while still using a social shaping model. Social shaping -like Kantian categories and for the same reason {Latour, 1992 #1164}- is adjusted only to times of stability. But when there is a sudden shift in the repertoire of capacities, a sudden new actor in the game, that is a novelty that cannot be accounted for through "prior commitments", then, out of despair, the same historians fall back on the realists's strategy. It is as if they needed, "every once in a

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<sup>32</sup> Alternation is actually defended as a viable solution by Collins {Collins, 1992 #1046}.

while”, as they so candidly say, to oil the social history machine with some new stuff leaking in from nature out there and literally grabbing the attention of otherwise prejudiced and committed scientists. From time to time, underdetermined facts are refreshed with overdetermined ones!

What is this dangerous hylozoism so elegantly criticized by Schaffer? The recognition that since all social constructivists let reality leak in anyway, why not finding new official ways to accompany the entry of non-humans into the fabrics of the collective. We might then start to account for their socialization, for the modification of the social link, for the transformation of humans actors and for the continuous innovation -instead of letting by spurts undocumented immigrants sneak in after dark before naturalizing them as citizen of the steady state of social order. Alternation as a philosophy of science studies has long outlived its usefulness and the obstinacy of my colleagues to stick to it fascinates me. What is so good about it? Apart from helping against the old fight against empiricism, it is of no use whatsoever for understanding sciences-societies mixtures.

I recognize, however, that its weaknesses are visible only if one, turning its attention away from the question of the non-humans, consider now those famous humans who are supposed to have the active part in the shaping of scientific facts. If we now turn to Pasteur’s politics we are going to realize how terribly flawed social constructivism is, not because of its treatment of non-humans, but because of its sociology. Its social theory is as implausible as its ontology and -as we will see later- of its history. I said at the beginning that this debate -the primary one between Pasteur and Pouchet and the secondary one between Schaffer and myself- offered an ideal test bed for the three disciplines of philosophy, sociology, and history. The solution I am groping for has a meaning only if the three questions are raised at once and the same time. Let us now turn to the second field.

The point is much easier to make because social historians practice asymmetry in a much more blatant way when they deal with society than when they deal with nature -retrained and reeducated as they have been in order to eradicate their own whiggish tendencies (I keep inside the inquisition vocabulary for the sake of homogeneity). They let reality reluctantly leak in but society just gushes in... What they have learned to abhor when nature is in question they happily embrace when society is to be wheeled in to balance the account that the underdeterminacy of facts has left in the red. That there exist a unified social context up there does not bother them in the least -whereas a unified nature out there horrifies them.

**(la suite au prochain numéro...)**

the reason why sociology is necessary is the question of plasticity, underdetermined facts and overdetermined society, but society is an artefact, it is itself too weak, how could it regain stability, by artefacts, but where are they, captive on the other side in nature, forbidden to use, this is why freeing nhs from the dictatyre of realism is so important, it renders them available again for the construction of focial order;

order is this: alternation is insufficient, then symmetry, but then nh are freed to explain in part social order stability and we are back in business with a non dialectical dialectics

but then the question of history is open if its networks then what is their temporal historicity? extnsion in space time envelop of phenomena come back on the brief history of the microbe as a spatio temporal network envelop -not as always everywhere.