CHAPTER X

Laboratory Experiments

We have already seen that at the time when Béchamp and Pasteur turned their attention to the subject of fermentation, the vaguest conceptions were held in regard to living matter. Grand names were given, such as protoplasm and *blastème,* but so little was known that the albuminoids were believed to be always identical. Virchow had tried to simplify matters by declaring that the living units of animal and vegetable forms are the cells of the body, and while Henle advanced considerably farther by stating that, on the contrary, the cells are themselves built up by minute atoms, the molecular granulations, just distinguishable within them. Schwann had also taught that the atmosphere is filled with infinitesimal living organisms. Then Béchamp and Pasteur appeared on the scene, the latter first of all affirming the spontaneous origin of ferments, while at the same time Béchamp irrefutably demonstrated that yeast and other organisms are air-borne. Finally Pasteur, converted by Béchamp's illuminating views, became enthusiastic over atmospheric germs and, as we have seen, before a fashionable assembly took to himself the whole credit of their elucidation. Yet so little was he really enlightened that we find him soon afterwards denying the parasitic origin of a complaint, *pébrine,* which was genuinely provoked by a parasite, while in the opposite direction his conception of living matter was no farther advanced from the old-fashioned view that held the living body to be nothing more than a kind of chemical apparatus. For him in the body there was nothing actually alive; its wonderful workings never suggested to him living autonomous agents.

Of course, in excuse, it may well be said that there was no reason why Pasteur should have understood the body. He never received any medical, phyisiological or biological training and had no pretensions to being a naturalist. Chemist though he was, he seems to have had no intutitve sharpness for the branch of science to which he turned his attention. When he took his degree of Bachelor of Science, his examiner appended a note to his diploma stating that he was only "mediocre in chemistry."

He does not seem even to have been particularly quick in grasping the ideas of other people, for we have seen what a long time it took before he realised the correctness of Béchamp's explanation of *pébrine*. It was in worldly wisdom that his mind was acute. Fortune favoured him, and he was always on the alert to seize opportunities; but, sad to say, it seems that he was not above pushing himself at someone else's expense, even though the progress of science were thereby hampered, and we can only deplore this misuse of his admirable persistence and energy.

While Pasteur learned nothing more about life than the fact that there are living organisms in the air, Professor Béchamp continued his untiring experiments. Fate was kind in bringing to his help Professor Estor, another worker fully qualified by training and experience. The two scientists were hard-working men, with their minds well exercised by their daily toil, their very discoveries bred, in many cases, by their clinical observations. Béchamp made discoveries in the same way that a Beethoven composes, a Raphael paints and a Dickens writes; that is to say, because he could not help himself, he could not do otherwise. In pathetic contrast, we find men to-day taken away from practical work and set down in laboratories *to make discoveries.* In many cases they have mediocre minds which could never originate an idea of any sort. All they can follow are routine theories and their so-called "discoveries" are of the type that pile up error upon error. Provide a man with his practical work, and if he have the discoverer's rare insight, as night yields to day, so will practice gain enlightenment. What is urgently needed is freedom from dogma and the encouragement of original opinions. Minds in a mass move at a snail's crawl, and the greatest impediment, no doubt, to Béchamp's microzymian doctrine was the fact that it so utterly outstripped the scientific conceptions of that period.

What he did, first and foremost, was to lay the foundations of what, even to-day, is a new science—that of cytology.

Having made his surprising discovery of the minute organisms, agents of fermentation, in chalk, Béchamp's next work was a thorough investigation of the "molecular granulations" of cells with which he connected the "little bodies" of chalk and limestone. Up to this date Henle's vague views regarding the granulations had been ignored and they were generally considered to be mere formless, meaningless particles. Calling the microscope and polarimeter to his aid and undertaking innumerable chemical experiments, Professor Béchamp, making use at first principally of such organisations as yeast, found the granulations which they contain to be agents provocative of fermentation, and then bestowed on them the explanatory name of microzyma. These same granulations he found in all animal and vegetable cells and tissues and in all organic matter, even though apparently not organised, such as milk, in which he proved them to account for the chemical changes that result in the milk clotting. He found the microzymas teeming everywhere, innumerable in healthy tissues, and in diseased tissues he found them associated with various kinds of bacteria. One axiom he laid down[1] was that though every microzyma is a molecular granulation, not every molecular granulation is a microzyma. Those that are microzymas he found to be powerful in inducing fermentation and to be possessed of some structure. In short, it was made clear to him that they, not the cell, are the primary anatomical elements.

It was never his practice to let his imagination outstrip his experiments. Invariably he propounded his question and waited for facts to make answer. Working with Professor Estor, observations showed that not only are the molecular granulations, the microzymas, anatomical elements, autonomously living, with organisation and life inseparably united in their minute selves, but that it is due to these myriad lives that cells and tissues are constituted living; in fact, that all organisms, whether the one-celled amœba in its pristine simplicity or man in his varied complexity, are associations of these minute living entities.

A modern text-book[2] well sums up Béchamp's primary teaching: "Their behaviour" (that of the molecular granulations, here named microsomes) "is in some cases such as to have led to the hypothesis long since suggested by Henle (1841) and at a later period developed by Béchamp and Estor and especially by Altmann, that microsomes are actually units or bioblasts, capable of assimilation, growth and division, and hence to be regarded as elementary units of structure, standing between the cell and the ultimate molecules of living matter."

Only some such discovery could clear away the confusion on the subject of spontaneous generation. Superficial observers, among whom we are forced to include Pasteur, continued to

[1] *Les Microzymas, par A. Béchamp,* p. 133.
[2] *The Cell in Development and Inheritance,* by Edmund B. Wilson, Ph.D., p. 290.

maintain that fermentation was only induced by germs from the air; but at the same time Pasteur had to admit that meat, protected from atmospheric contact in an experiment of his own, none the less became tainted. Other experimenters insisted upon changes taking place for which atmospheric organisms could not be held responsible.

Béchamp, the first to make clear the fermentative rôle of air-borne agents, was now able, according to his own views, to explain that fermentation might take place apart from these, for all organisms teem with minute living entities capable of producing ferments, and that in fact those found in the air he believed to be simply the same released from plant and animal forms, which they have first built up, but from which they are afterwards freed by that disruption we call death. The two Professors of Montpellier, working together, began to trace and follow life in its marvellous processes.

At the risk of being wearisome by repetition, we must remind ourselves of the order in which Béchamp achieved his early discoveries. First, he demonstrated that the atmosphere is filled with minute living organisms, capable of causing fermentation in any suitable medium which they chance to light upon, and that the chemical change in the medium is effected by a ferment engendered by them, which ferment may well be compared to the gastric juice of the stomach. Secondly, he found in ordinary chalk, and afterwards in limestone, minute organisms capable of producing fermentative changes, and showed these to bear relation to the infinitesimal granulations he had observed in the cells and tissues of plants and animals. He proved these granulations, which he named microzymas, to have independent individuality and life, and claimed that they are the antecedents of cells, the upbuilders of bodily forms, the real anatomical, incorruptible elements. Thirdly, he set forth that the organisms in the air, the so-called atmospheric germs, are simply either microzymas or their evolutionary forms set free by disruption from their former vegetable or animal habitat, and that the "little bodies" in the limestone and chalk are the survivors of the living forms of past ages. Fourthly, he claimed that, at this present time, microzymas constantly develop into the low type of living organisms that go by the name of bacteria.

We have already superficially studied the rigid experiments that established Béchamp's views on the fermentative rôle of air-borne organisms and of those found in chalk; let us now follow

a very few of the innumerable experiments he carried out in the establishment of his other conclusions. His work was so incessant, his observations so prolific, that only their fringe can be touched and no attempt can be made to trace the exact chronological order of the experiments upon which he based his opinions.

At a very early stage of his researches he demonstrated with Professor Estor that air need have nothing to do with the appearance of bacteria in the substance of tissues. Further, these investigators established the independent vitality of the microzymas of certain tissues, certain glands, and so forth, by showing that these minute granules act like organised ferments and that they can develop into bacteria, passing through certain intermediary stages which they described, and which intermediate stages have been regarded by many authorities *as different species*.

We have seen that the basic solution of the whole secret for Béchamp was his discovery of the "little bodies" in chalk, which possess the power of inverting cane-sugar, liquefying starch, and otherwise proving themselves agents of fermentation. The strata in which he found them were regarded by geologists as having an antiquity of at least eleven million years, and Béchamp questioned whether the "little bodies" he had named *microzyma cretæ* could really be the surviving remains of the fauna and flora of such long-past ages. Not having centuries at his disposal to test the problem, he determined to see for himself what would remain now at this present time of a body buried with strict precautions. He knew that, in the ordinary way, an interred corpse was soon reduced to dust, unless embalmed or subjected to a very low temperature, in which cases the check to decomposition would be explained by the inherent granules, the microzymas, becoming dormant.

[1]At the beginning of the year 1868 he therefore took the carcass of a kitten and laid it in a bed of pure carbonate of lime, specially prepared and creosoted, while a much thicker layer covered the body. The whole was placed in a glass jar, the open top of which was closed by several sheets of paper placed in such a way that air would be continually renewed without permitting the intrusion of dust or organisms. This was left on a shelf in Béchamp's laboratory until the end of the year 1874. The upper bed of carbonate of lime was then removed and proved to be entirely soluble in hydrochloric acid. Some centimeters farther down there were only to be found some

[1] See *Les Microzymas, par A. Béchamp*, p. 625 and onwards.

fragments of bone and dry matter. Not the slightest smell was perceptible, nor was the carbonate of lime discoloured. This artificial chalk was as white as ordinary chalk, and, except for the microscopic crystals of aragonite found in precipitated carbonate of lime, indistinguishable from it, and showed under the microscope brilliant "molecules," such as those seen in the chalk of Sens. One part of this carbonate of lime was then placed in creosoted starch, and another part in creosoted sweetened water. Fermentation took place just as though ordinary chalk had been used, but more actively. Microzymas were not seen in the upper stratum of the carbonate of lime, but in that portion where the kitten's body had rested they swarmed by thousands in each microscopic field. After filtering the carbonate of lime through a silken sieve it was taken up with dilute hydrochloric acid, and Béchamp thereby succeeded in separating the microzymas which had been made visible by the microscope.

At the end of this experiment, which had continued for over six and a half years, Béchamp, with "the infinite patience of genius," repeated it by another which lasted seven years.

To meet the possible criticism that the body of the kitten had been the prey of germs of the air which might have been carried in its hair or admitted into its lungs by breathing when alive, or into its intestinal canal, Béchamp now repeated his experiment with more rigid precautions.

This time, in addition to burying the whole carcass of a kitten, he also buried, in one case, a kitten's liver, and in another the heart, lungs and kidneys. These viscera had been plunged into carbolic acid the moment they had been detached from the slaughtered animal. This experiment, commenced in the climate of Montpellier in the month of June 1875, had to be transported to Lille at the end of August 1876 and was terminated there in August 1882.

Owing to the temperate climate of Lille, very different from that of Montpellier, which for a great part of the year is almost sub-tropical, the destruction of the body was much less advanced in this later experiment than it had been in the previous one. All the same, in the beds of carbonate of lime near the remains, in one case of the whole kitten and in the other of the viscera, microzymas swarmed and there were also well-formed bacteria. Moreover he chalk was impregnated with organic matter, which coloured it a yellowish brown, but the whole was odourless.

From these two experiments Béchamp found great confirmation of views that had been already suggested to him by many other observations. To begin with, they supported his belief that the "little bodies," the microzymas, of natural chalk are the living remains of the plant and animal forms of which in past ages they were the constructive cellular elements. It was shown that after the death of an organ its cells disappear, but in their place remain myriads of molecular granulations, otherwise microzymas. Here was remarkable proof of the imperishability of these builders of living forms. Neither is the fact of their own independent life denied by a longevity under conditions that would debar them from nutrition throughout immense periods, since we find prolonged abstention from food to be possible even in the animal world among hibernating creatures, while the naturalist can detail many more cases among minute organisms—for instance pond-dwellers, which fast for indefinite intervals when deprived of water, their natural habitat, and fern-spores, which also are known to retain a vitality that may lie dormant for many years. Thus, whether confined within some animal or vegetable body, or freed by the disruption of plant and animal forms, the microzymas, according to Béchamp, were proved capable of preserving vitality in a dormant state even though the period surpassed men's records. It would still be possible for different microzymas to possess varying degrees of vitality, for, as we shall see, Béchamp found differences between the microzymas of various species and organs.

But, over and above finding that the elements of the cells can live on indefinitely after the disruption of the plant or animal bodies that they originally built up, he considered that he had obtained convincing evidence of their capability of developing into the low types of life known as bacteria. If not, where did these come from in the case of the buried viscera? Even if air-borne germs were not completely excluded in the case of the kitten's body, the utmost precautions had been taken to exclude them in the case of the burial of the inner organs. Yet Béchamp found that the microzymas of the viscera, as well as those of the whole kitten, had evolved into associated microzymas, chaplets of microzymas, and finally into fine bacteria, among which the *bacterium capitatum* appeared in the centre of a great piece of flesh.

Here Béchamp saw how wrong first the great naturalist Cuvier and after him Pasteur had been in assuming "That any part whatever, being separated from the mass of an animal, is by that fact transferred into the order of dead substances and is thereby essentially changed." By Béchamp's researches it was seen that separate parts of a body maintain some degree of independent life, a belief held by certain modern experimenters who, unlike Béchamp, however, fail to provide an explanation.

His experiment showed the Professor how it is that bacteria may be found in earth where corpses have been buried and also in manured lands and among surroundings of decaying vegetation. According to him bacteria are not specially-created organisms mysteriously appearing in the atmosphere, but they are the evolutionary forms of microzymas, which build up the cells of plants and animals. After the death of these latter the bacteria, by their nutritive processes, bring about the disruption, or in other words the decomposition, of the plant or animal, resulting in a return to forms approximating to microzymas. Thus Béchamp taught that every living being has arisen from the microzyma, and also that "every living being is reducible to the microzyma."[1] This second axiom of his, he says, accounts for the disappearance of bacteria in the earlier experiment, for just as microzymas may evolve into bacteria, so according to his teaching, bacteria, by an inverse process, may be reduced to the pristine simplicity of the microzyma. Béchamp believed this to have happened in the earlier case, when the destruction of the kitten's carcass was so much more complete than in the second case, when the temperate climate of Lille had prolonged the process of decomposition.

FROM DUST TO DUST

Many indeed were the lessons the indefatigable worker learned from these two series of observations.[2]

1. "That the microzymas are the only non-transitory elements of the organism, which persist after the death of the latter and form bacteria.

2. "That there is produced in the organisms of all living beings, including man, in some part and at a given moment, alcohol, acetic acid and other compounds that are normal products of the activity of organised ferments, and that there is no other natural cause of this production than the normal microzymas of the organism. The presence of alcohol, of acetic acid, etc., in the tissues, reveals one of the causes, independent of the phenomenon of oxidation, of the disappearance of sugar in the organism and of the disappearance of the gluco-genic matters and that which Dumas called the respiratory foods.

3. "That, without the concurrence of any outside influence except

[1] *Les Microzymas*, p. 925. [2] *ibid.*, pp. 628-630.

a suitable temperature, fermentation will go on in a part withdrawn from an animal, such as the egg, milk, liver, muscle, urine, or, in the case of plants, in a germinating seed, or in a fruit which ripens when detached from the tree, etc. The fermentable matter that disappears earliest in an organ after death is the glucose, glucogenic matter or some other of the compounds called carbo-hydrate, that is to say, a respiratory food. And the new compounds that appear are the same as those produced in the alcoholic, lactic and butyric fermentations of the laboratory; or, during life, alcohol, acetic acid, lactic or sarcolactic acid, etc. . . .

4. "That it is once again proved that the cause of decomposition after death is the same, within the organism, as that which acts, under other conditions, during life, namely, microzymas capable of becoming bacteria by evolution.

5. "That the microzymas, after or before their evolution into bacteria, only attack albuminoid or gelatinous matters after the destruction of the matters called carbohydrates.

6. "That the microzymas and bacteria, having effected the transformations before mentioned, do not die in a closed apparatus in the absence of oxygen; they go into a state of rest, as does the beer-yeast in an environment of the products of the decomposition of the sugar, which products it formed.

7. "It is only under certain conditions, particularly in the presence of oxygen, as in the experiment on the kitten buried in carbonate of lime, etc., that the same microzymas or bacteria effect the definite destruction of vegetable or animal matter, reducing it into carbonic acid, water, nitrogen, or simple nitrogenous compounds, or even into nitric acid, or other nitrates!

8. "That it is in this way that the necessary destruction of the organic matter of an organism is not left to the chances of causes foreign to that organism, and that when everything else has disappeared, bacteria, and, finally, microzymas resulting from their reversion remain as evidence that there was nothing of what was primarily living except themselves in the perished organism. And these microzymas, which appear to us the remains or residuum of that which has lived, still possess some activity of the specific kind that they possessed during the life of the destroyed being. It is thus that the microzymas and bacteria that remained from the corpse of the kitten were not absolutely identical with those of the liver or of the heart, of the lung or of the kidney."

The Professor continued: "I do not mean to infer that in destruction effected in the open air, on the surface of the ground, other causes do not occur to hasten it. I have never denied that the so-called germs of the air or other causes are contributory. I only say that these germs and these causes have not been expressly created for that purpose and that the so-called germs in atmospheric dusts are nothing else than the microzymas from organisms destroyed by the mechanism I have just explained and whose destructive influence is added to that of the microzymas belonging to the being in process of destruction. But in the atmospheric dusts there are not only the microzymas; the spores of the entire microscopic flora may intrude, as well as all the moulds that may be born of these spores."

It must not be supposed that Béchamp founded such manifold views upon any mere two series of observations. From the date of his Beacon Experiment he never ceased from arduous work in connection with micro-organisms. Together with Professor Estor he instituted many experiments upon inner organs subtracted from fœtuses, accidentally provided for them by abortions. Here again they had overwhelming proof of bacterial evolution from normal inherent particles, for, while they would find bacteria in the interiors, the surrounding liquids, specially prepared as accepted culture media, would be absolutely free from such organisms. They spared themselves no trouble. Space does not allow of more than a trifling reference to a very few of their continual and varied experiments, such, for instance, as those upon eggs, in which, not contenting themselves with hens', they procured ostrich eggs with their hard tenacious shells and subjected these to innumerable tests. From the latter they received evidence of the gradual evolution in the fecundated egg of the united microzymas of the male sperm and female germ cells into the organs and tissues of the resultant feathered creature. They were also shown the arrest of this development in eggs that were shaken and disturbed and the internal substitution in the rotting egg of chaplets of associated microzymas and swarming bacteria.

In the course of their work the Professors applied every possible test to their experiments, sometimes admitting air and sometimes rigorously excluding it. Their observations began to be enthusiastically taken up by some of Professor Béchamp's pupils, numbered among whom was M. Le Rique de Monchy, who assisted Béchamp with his silkworm researches. In a paper called[1] "Note on the Molecular Granulations of Various Origin," this indefatigable student demonstrated that the vibrating granulations are organisms having an energetic action similar to that of ferments upon certain of the matters with which they are in contact in their natural medium.

[1] *Comptes Rendus de l'Académie des Sciences* 66, p. 550.

Meanwhile, his great teacher sent up Memoir after Memoir to the Academy of Science. It was Béchamp who initiated the study of micro-organisms—microzymas and bacteria—in saliva and in the mucus of the nasal and other passages. The very secretions of the body afforded him proof of his opinions. Thus, in a Memoir "On the Nature and Function of the Microzymas of the Liver," he and Estor said:[1] "Matter, whether albuminoid or other, never spontaneously becomes a zymase or acquires the properties of zymases; wherever these appear some organised (living) thing will be found."

What a wonderful conception this gives of the body! Just as a household or a State cannot prosper without its different members undertaking their varied functions, so our bodies and those of animals and plants are regulated by innumerable workers whose failure in action disturbs the equilibrium of the entire organism. Just as in the State there are different experts for different forms of labour, so Béchamp demonstrated the differentiation between the microzymas of various organs, the microzymas of the pancreas, the microzymas of the liver, the kidneys, etc., etc. And since it may be objected that it is too difficult to make such distinctions between microscopic minutiæ, we cannot do better than quote the words of the brilliant experimenter.

"The naturalist," said Béchamp,[2] "will not know how to classify them, but the chemist who studies their functions can do so. Thus a new road is opened: when the microscope becomes powerless to show us among known forms the cause of the transformation of organic matter, the piercing glance of the chemist armed with the physiological theory of fermentations will discover behind the chemical phenomena the cause that produces them." Again he said: "The microzymas can only be distinguished by their function, which may vary even for the same gland and for the same tissue with the age of the animal."[3]

He also showed that they vary for each tissue and for each animal, and that the microzymas found in human blood differ from those found in the blood of animals.

These researches were arousing so much attention that in 1868 Professor Béchamp was invited by M. Glenard, the Director, to give a special lecture at the School of Medicine at Lyons. On this occasion the great Master discussed the experiments upon

[1] *Comptes Rendus de l'Académie des Sciences* 66, p. 421 (1868).
[2] *La Théorie du Microzyma*, p. 116.
[3] *Les Grands Problèmes Médicaux, par A. Béchamp*, p. 61.

the microzymas of the liver which he and Professor Estor had conducted together, as well as the rôle that the microscopic organisms of the mouth play in the formation of salivary diastase and in the digestion of starches, which work he had undertaken in connection with Professor Estor and M. Sainte-Pierre. He also pointed out the microzymas in vaccine and in syphilitic pus.

These were the days in which Béchamp was happy in his work at Montpellier, when the star of hope still gleamed, and he displayed the bright cheerfulness habitual to his temperament. We can picture him, with his noble face and large idealistic eyes shining with enthusiasm, as he lectured to his young audience at Lyons. There was never a word of self; of what he had done or hoped to do. Boastings or mock humilities were equally foreign to him. The mysteries of Nature, the workings of life and death, absorbed him. And so the students dispersed with their minds filled with the wonders they had heard and which so far outstripped what they had otherwise learned that the full meaning, no doubt, barely went home and they had small idea of the genius of the great man, devoid of self-praise, who had lectured so unostentatiously to them.

What wonderful times those were for the great teacher when his views developed with such rapidity, and continuously by day and often half through the night he worked at the unravelling of Nature's mysteries; while with him for a series of years toiled his devoted colleague Professor Estor.

"Ah! how moving," wrote Béchamp,[1] "were the innumerable *séances* at which we assisted, amazed by the confirmation of ideas, the verification of facts, and the development of the theory." And with that large-hearted generosity as natural to him as it was alas! foreign to Pasteur, he added: "During the period from 1868 to 1876 all that concerns the microzymas of animal organs was common to both of us, and I do not know how to distinguish between what is mine and what is Estor's."

We can faintly realise the emotion of the discoverers as they found themselves penetrating closer to the secrets of life than any man had succeeded in doing before them; exemplifying and proving that which the great Lavoisier had felt after in an earlier epoch. And, since they were both doctors, their labours were not narrowed to the more or less artificial experiments they undertook in the laboratory. Their clinical work brought them constant experience, and their surest observations were those accomplished by the greatest of all experimenters—Nature!

[1] *La Théorie du Microzyma,* p. 123.