PART TWO
THE MICROZYMAS

CHAPTER VIII

The "Little Bodies"

Just as certain musicians seem born with a natural facility for a particular instrument, so in the world of science from time to time men arise who appear specially gifted in the use of technical instruments. It was, no doubt, Professor Béchamp's extraordinary proficiency as a microscopist, as well as the insight of genius, that enabled him from the start of his work to observe so much that other workers ignored when employing the microscope; while his inventive brain led to an application of the polarimeter which greatly assisted him. His powers combined in a remarkable degree the practical and theoretical. Instead of failing, like many men of big brain capacity, when manual dexterity was needed, the Professor's deft fingers and keen-sighted eyes were ever the agile assistants of his mighty intellect.

From the time of his earliest observations he was quick to notice minute microscopic objects much smaller in size than the cells of the organisms he examined. He was by no means the first to observe these; others had done so before him; but although they applied to them such names as "scintillating corpuscles," "molecular granulations," and so forth, no one was much the wiser as to their status and function. Most of what had been said about them was summed up in Charles Robin's definition in the *Dictionary of Medicine and Surgery* (1858), in which he described the minuteness of "very small granulations formed of organised substance" found in the tissues, cells, fibres and other anatomical elements of the body, and in great abundance in tuberculous substances and other disease matters.

Béchamp, always so careful to avoid unsubstantiated conclusions, did not allow his imagination to run away in regard to them. He at first merely noted them and bestowed upon them the noncommittal name of "little bodies." He had no further enlightenment in regard to them at the time when his new duties took him to Montpellier, and he there brought to a close the observations that he had commenced at Strasbourg and which he recounted and explained in his Memoir of 1857. It will be remembered that for many of these experiments the Professor employed various salts, including potassium carbonate, in the presence of which the inversion of cane-sugar did not take place, in spite of the absence of creosote. Another experiment that he made was to substitute for potassium carbonate calcium carbonate in the form of chalk. Great was his surprise to find that in spite of the addition of creosote, to prevent the intrusion of atmospheric germs, cane-sugar none the less underwent inversion, or change of some sort. In regard to creosote, Béchamp had already proved that though it was a preventive against the invasion of extraneous organisms, it had no effect in hampering the development of moulds that were already established in the medium. The experiments in which he had included chalk seemed, however, to contradict this conclusion, for in these cases creosote proved incapable of preventing the inversion of sugar. He could only believe that the contradiction arose from some faultiness of procedure; so he determined to probe further into the mystery and meanwhile to omit from his Memoir any reference to the experiments in which chalk had proved a disturbing factor.

The work that Professor Béchamp undertook in this connection is an object lesson in painstaking research. To begin with he had first chalk and afterwards a block of limestone conveyed to his laboratory with great precautions against any air coming into contact. To continue, he proved by innumerable experiments that when all access of air was entirely shut away, no change took place in a sugar solution even when chemically pure calcium carbonate, $CaCO_3$, was added, but directly ordinary chalk, even from his specially conserved block, was introduced fermentation took place although the entry of atmospheric germs had been guarded against completely. No addition of creosote even in increased doses could then prevent the inversion of the sugar.

Béchamp was naturally extremely surprised to find that a mineral, a rock, could thus play the part of a ferment. It was clear to him that chalk must contain something over and above calcium carbonate. He therefore called to his help his good ally the microscope. Working with the highest power obtainable, he undertook a minute investigation both of pure calcium carbonate and of the chalk he had used for his experiments. Great

was his amazement to find in the latter "little bodies," similar to those he had noted in other observations, while nothing of the sort was to be seen in the former. Also, while in the microscopic preparation of the calcium carbonate everything was opaque and motionless, in that of the chalk the "little bodies" were agitated by a movement similar to that known as "Brownian" after the naturalist Robert Brown, but which Béchamp differentiated from it.[1] These "little bodies" were distinguishable by the way in which they refracted light from their opaque surroundings. They were smaller than any of the microphytes seen up to that time in fermentations, but were more powerful as ferments than any known, and it was because of their fermentative activity that he regarded them as living.

To form any correct estimate of the magnitude of the discovery upon the brink of which Béchamp hovered, we must remind ourselves of the scientific opinions of the epoch. The Professor's observations were made at a date when most believed in Virchow's view of the cell as the unit of life in all forms, vegetable and animal, and sponteparist opinions were held by a large body of experimenters, including at that time Pasteur. In the midst of this confusion of ideas Béchamp clung firmly to two axioms: Firstly, that no chemical change takes place without a provocative cause. Secondly, that there is no spontaneous generation of any living organism. Meanwhile, he concentrated his mind upon the "little bodies."

He realised at the start that if those he had discovered in chalk were really organised beings, with a separate independent life of their own, he ought to be able to isolate them, prove them to be insoluble in water, and find them composed of organic matter. He succeeded in isolating them and proved carbon, hydrogen, etc., to be their component parts and demonstrated their insolubility. If they were living beings it followed that it must be possible to kill them. Here again he found the truth of his contention, for when he heated chalk together with a little water to 300° C. (572° F.), he afterwards proved it to have become devoid of its former fermentative power. The "little bodies" were now quite devoid of the movement that before had characterised them. Among other points, he discovered that if during the process of fermentation by these minute organisms all foreign invasions were guarded against by rigid precautions, the

[1] *La Théorie du Microzyma, par A. Béchamp*, p. 115.

little bodies increased and multiplied. This observation was to stand him in good stead in his subsequent[1] researches.

Béchamp observed that the chalk he had used seemed to be formed mostly of the mineral remains of a microscopic world long since vanished, which fossil-remains, according to Ehrenberg, belong to two species called *Polythalamis* and *Nautilæ,* and which are so minute that more than two millions would be found in a piece of chalk weighing one hundred *grammes.* But, over and above these remains of extinct beings, the Professor saw that the white chalk contains organisms of infinitesimal size, which according to him are living and which he imagined might possibly be of immense antiquity. The block of limestone he had obtained was so old that it belonged to the upper lacustrian chalk formation of the Tertiary Period; yet he proved it to be possessed of wonderful fermentative properties which he satisfied himself to be due to the presence of the same "little bodies."[2]

He continued a persistent examination of various calcareous deposits, and not only found the same minute organisms, but discovered them to possess varying powers of causing fermentation. The calcareous tufa and the coal areas of Bessège had very little power either to liquefy starch or to invert cane-sugar; while on the other hand the peat-bogs and the waste moors of the Cévennes, as well as the dust of large cities, he proved to contain "little bodies" possessing great powers for inducing fermentation. He continued his investigations and found them in mineral waters, in cultivated land, where he saw that they would play no inconsiderable rôle, and he believed them to be in the sediment of old wines. In the slime of marshes, where the decomposition of organic matter is in progress, he found the "little bodies" in the midst of other inferior organisms, and, finding also alcohol and acetic acid, attributed to these minute living beings the power that effects the setting free of marsh-gas.

Nature having confided such wonderful revelations, the time had come for Professor Béchamp to allow his mind to interpret their meaning. The experiments he had omitted from his great Memoir, instead of being faulty, now seemed to hold marvellous suggestions. The "little bodies" he had discovered in the chalk appeared to be identical with the "little bodies" he had observed in the cells of yeast and in the body-cells of plants and animals, the "little bodies" that for the most part went by the name of

[1] *La Théorie du Microzyma, par A. Béchamp,* pp. 113, 114.
[2] *Les Microzymas, par A. Béchamp,* pp. 940, 944.

"molecular granulations." He remembered that Henle had in a vague way considered these granulations to be structured and to be the builders of cells; and Béchamp saw that, if this were true, Virchow's theory of the cell as the unit of life would be shattered completely. The granulations, the "little bodies," would be the anatomical elements, and those found in the limestone and chalk he believed might even be the living remains of animal and vegetable forms of past ages. These must be the upbuilders of plant and animal bodies and these might survive when such corporate bodies have long since undergone disruption.

At this point we may draw attention to the cautiousness of Béchamp's proceedings. Although his investigations of chalk were commenced at the time of the publication of his Beacon Memoir, he continued to work at the subject for nearly ten years before giving publicity to his new observations. Meanwhile the proverb about the ill wind was exemplified in his case, for diseases affecting vines were becoming the scourge of France, and led him to undertake some experiments that were helpful in widening the new views that he was gradually formulating.

We have already seen how in 1863 M. Pasteur had been despatched with the Emperor's blessing to investigate the troubles of the French wine-growers. There was no official request for Professor Bechamp's assistance, but, none the less, with his unfailing interest in all scientific problems he started to probe into the matter, and in 1862, a year before Pasteur, began his researches in the vineyard.

He exposed to contact with air at the same time and place (1) grape-must, decolourised by animal charcoal; (2) grape-must simply filtered; and (3) grape-must not filtered. The three preparations fermented, but to a degree in an inverse order from the above enumeration. Further, the moulds or ferments that developed were not identical in the three experiments.

The question thus arose: "Why, the chemical medium being the same in the three cases, did it not act in the same manner upon the three musts?"

To solve the riddle the Professor instituted more experiments. Whole healthy grapes, with their stalks attached, were introduced direct from the vine into boiled sweetened water, cooled in a current of carbonic acid gas, while the gas still bubbled into the liquid. Fermentation took place and was completed in this medium, preserved during the whole process from the influence of air. The same experiment succeeded when the grapes were introduced into must, filtered, heated and creosoted.

From these researches it was evident that neither oxygen nor air-borne organisms were the cause of the fermentation, but that the grape carried with it the provocative agents.

Professor Béchamp communicated the results of his experiments to the Academy of Science in 1864, and among its Reports the subject may be found exhaustively treated.[1] He had come to the conclusion that the agent that causes the must to ferment is a mould that comes from the outside of the grape, and that the stalks of grapes and the leaves of vines bear organisms capable of causing both sugar and must to ferment; moreover, that the ferments borne on the leaves and stalks are sometimes of a kind to injure the vintage.

The year 1864, when Béchamp presented his Memoir, marks an era in the history of biological research, for on the 4th April of that self-same year he read before the Academy of Science his explanation of the phenomena of fermentation. He showed the latter to be due to the processes of nutrition of living organisms, that absorption takes place, followed by assimilation and excretion, and for the first time used the word *zymase* to designate a soluble ferment.

It was the following year that M. Duclaux, a pupil of Pasteur's, tried to cast scorn upon Béchamp's illuminating explanation, thus supplying documentary proof that his master had no right to lay claim to having been a pioneer of this teaching.

Béchamp, who in 1857 had so conclusively proved air-borne organisms to be agents of fermentation, now in 1864 equally clearly set forth the manner in which the phenomenon is induced. All the while he was at work on Nature's further mysteries, undertaking experiments upon milk in addition to many others, and in December of the same year informed M. Dumas of his discovery of living organisms in chalk. Later, on the 26th September, 1865, he wrote to M. Dumas on the subject, and by the latter's request his letter was published the next month in the *Annales de Chimie et de Physique*.[2]

Here he stated: "Chalk and milk contain living beings already developed, which fact, observed by itself, is proved by this other fact that creosote, employed in a non-coagulating dose, does not prevent milk from finally turning, nor chalk, without extraneous

[1] *Comptes Rendus* 59, p. 626.
[2] *4e série*, 6, p. 248.

help, from converting both sugar and starch into alcohol and then into acetic acid, tartaric acid and butyric acid."

Thus we clearly see the meaning in every single experiment of Béchamp's and the relation that each bore to the other. His rigid experiments with creosote made it possible for him to establish further conclusions. Since creosote prevented the invasion of extraneous life, living organisms must be pre-existent in chalk and milk before the addition of creosote. These living organisms were the "little bodies" that he had seen associated in cells and singly in the tissues and fibres of plants and animals. Too minute to differentiate through the microscope, Béchamp tells us[1] that: "The naturalist will not be able to distinguish them by description; but the chemist and also the physiologist will characterise them by their function."

He was thus not checked in his investigations by the minuteness of his objects of research, so infinitesimal as in many cases, no doubt, to be ultra-microscopic. Neither was he disturbed by the ridicule with which many of his contemporaries received his account of the "little bodies" in chalk and milk. Being a doctor, he was much helped in his research work by his medical studies. In the year 1865 he found in fermented urine that, besides other minute organisms, there were little bodies so infinitesimal as to be only visible by a very high power of the microscope, obj. 7, oc. I, Nachet. He soon after found these same "little bodies" in normal urine.

The following year, 1866, he sent up to the Academy of Science a Memoir entitled "On the Rôle of Chalk in Butyric and Lactic Fermentations and the Living Organisms Contained in It."[2]

Here he detailed experiments and proposed for the "little bodies" the name of *microzyma*, from Greek words that mean "small" and "ferment." This very descriptive nomenclature portrayed them as ferments of the minutest perceptible order.

To the special "little bodies" found in chalk he gave the name of *microzyma cretæ*.

Without loss of time he continued his investigations on the relation of the mycrozymas of chalk to the molecular granulations of animal and vegetable cells and tissues, and also made numerous further geological examinations. The results of the latter were partly incorporated in a Memoir "On Geological Micro-

[1] *La Théorie du Microzyma, par A. Béchamp*, p. 124.
[2] *Comptes Rendus* 63, p. 451. *Les Microzymas, par A. Béchamp*, p. 940.

zymas of Various Origin," an extract of which was published among the Reports of the Academy of Science.[1]

In this he asks: "What is now the geological significance of these microzymas and what is their origin?" He answers: "I believe that they are the organised and yet living remains of beings that lived in long past ages. I find proof of this both in these researches and in those that I have carried out by myself and in collaboration with M. Estor on the microzymas of actual living beings. These microzymas are morphologically identical, and even though there may be some slight differences in their activity as ferments, all the components that are formed under their influence are nevertheless of the same order. Perhaps one day geology, chemistry and physiology will join in affirming that the great analogies that there are stated to be between geological fauna and flora and living fauna and flora, from the point of view of form, exist also from the point of view of histology and physiology. I have already set forth some differences between geological microzymas of various origin: thus, while bacteria may appear with the limestone of Armissan and that of Barbentane, these are never developed in the case of chalk or of Oolithic limestone under the same circumstances. Analogous differences may be met with among the microzymas of living beings. . . . It is remarkable that the microzymas of limestones that I have examined are almost without action at low temperatures, and that their activity only develops between 35 and 40 degrees. A glacial temperature, comparable to that of the valley of Obi, would completely arrest this activity."

Though many ridiculed such new and startlingly original ideas and though many nowadays may continue to do so, we have to remember that the mysteries of chalk may well bear much more investigation. Modern geologists seem ready to admit that chalk possesses some remarkable qualities, that under certain conditions it produces movements that might evidence life and induce something like fermentation. Professor Bastian, though his inferences differ completely from Béchamp's, again confirms the latter's researches. We read in *The Origin of Life*[2] as follows: "We may, therefore, well recognise that the lower the forms of life—the nearer they are to their source—the greater is likely to have been the similarity among those that have been produced

[1] *Comptes Rendus* 70, p. 914. *Les Microzymas, par A. Béchamp*, p. 944.
[2] *The Origin of Life*, by H. Charlton Bastian, M.A., M.D., F.R.S., F.L.S., pp. 67, 68.

in different ages, just as the lowest forms are now practically similar in all regions of the earth. How, otherwise, consistently with the doctrine of evolution, are we to account for the fact that different kinds of bacilli and micrococci have been found in animal and vegetable remains in the Triassic and Permian strata, in Carboniferous limestone and even as low as the Upper Devonian strata? (See *Ann. des Sciences Nat.* (*Bot.*), *1896, II, pp. 275-349.*) Is it conceivable that with mere lineal descent such variable living things could retain the same primitive forms through all these changing ages? Is it not far simpler and more probable to suppose, especially in the light of the experimental evidence now adduced, that instead of having to do with unbroken descent from ancestors through these aeons of time as Darwin taught, and is commonly believed, we have to do, in the case of Bacteria and their allies, with successive new births of such organisms throughout these ages as primordial forms of life, compelled by their different but constantly recurring molecular constitutions to take such and such recurring forms and properties, just as would be the case with successive new births of different kinds of crystals?"

We have introduced this quotation merely to show the confirmation by Bastian of Béchamp's discovery of living elements in chalk and limestone, and must leave to geologists to determine whether infiltration or other extraneous sources do or do not account for the phenomena. If they do not, we might be driven to believe in Professor Bastian's explanation of successively recurring new births of chemical origin, were it not for Professor Béchamp's elucidation of all organised beings taking their rise from the microzymas, which we may identify with what are now known as microsomes when found in cells, whether animal or vegetable. Thus we see that Béchamp's teaching can explain appearances which without it can only be accounted for by spontaneous generation, as shown by Professor Bastian. Whether Béchamp was correct in his belief that the microzymas in chalk are the living remains of dead beings of long past ages is not a point that we care to elaborate. We wish to leave the subject of chalk to those qualified to deal with it and have only touched on it here because these initial observations of Professor Béchamp's were what led to his views of the cell, since confirmed by modern cytology, and to what may be termed his microzymian doctrine, which we are inclined to believe has been too much neglected by the modern school of medicine. Those disposed to ridicule

Béchamp may well ponder the fact that the first word rather than the last is all that has been said about micro-organisms. For instance, it is now claimed that in the same manner that coral is derived from certain minute sea-insects, so particular micro-organisms not only aid in the decomposition of rocks and in the formation of chalk and limestone, but play an active part in the forming of iron deposits.[1]

Though, as we have said, derided by some, Béchamp's work at this time was beginning to attract a great amount of attention, and midway through the sixties of the last century it gained for him an enthusiastic co-partner in his labours. This was Professor Estor, physician and surgeon in the service of the hospital at Montpellier, and who, besides being in the full swing of practical work, was a man thoroughly accustomed to research and abundantly versed in scientific theories. He had been astounded by the discoveries of Professor Béchamp, which he described as laying the foundation stone of cellular physiology. In 1865 he published in the *Messager du Midi* an article that placed in great prominence Béchamp's explanation of fermentation as an act of cellular nutrition. This conception made a sensation in Germany, for while in a sense confirming Virchow's cellular doctrine it showed the German scientist's view to be only partial.

[1] Attention has been drawn to a remarkable and up-to-date parallel of Béchamp's discovery of microzymas in chalk. See *The Iron and Coal Trades Review* for May 4th, 1923. In this, in an article on *Coal Miners' Nystagmus,* Dr. Frederick Robson puts forward a statement by Professor Potter "that there are in coal bacteria capable of producing gases, and that the gases isolated are methane, carbon dioxide and carbon monoxide, with heating up to 2 deg. C. (35 deg.-36 deg. F.). It would appear as if wood were capable of containing in its metamorphosed state (coal) the bacteria originally present in the tree stage of its existence. It is possible, too, that different kinds of orders of flora would give rise to the presence of different species of bacteria . . . possibly resident in the woody-fibred coal. . . . This idea of bacterial invasion of coal suggests that some degree of oxidation may be due to the great army of ærobic or anærobic bacteria which may give rise to oxidation and may be the genesis of coal gases in the pits, *i.e.* that oxidation is due to living organisms with increase of 2 deg. C. of heat. This has been disproved, but it is evident that bacteria exist. . . . There is evidence to show that at 100 deg. C. (212 deg. F.) all bacterial action ceases. If soft coals and bacterial invasion go hand in hand, in some kind of relationship, then as the coal measures become harder from east to west, the microbic invasion or content may diminish with the ratio of gaseous liberation."

Thus more modern corroboration is found of Béchamp's astounding discovery; while it is due to him alone that we may understand the origin of the so-called bacteria. According to his teaching, these must be the surviving microzymas, or microsomes, of the cells of pre-historic trees, known to us now in their fossilised form as coal, but still preserving intact the infinitesimal lives that once built up primeval vegetation.

Béchamp's star was perhaps just now at its zenith. Conscious that his great discovery, as he proceeded with it, would illumine the processes of life and death as never before in the course of medical history, he was also happy in finding a zealous coadjutor who was to share in his work with persistence and loyalty, while at the same time a little band of pupils arose full of eagerness to forward their great Master's researches. Indistinguishable in the distance loomed a tiny cloud that on gathering was to darken his horizon. France was in trouble. Her whole silk industry was threatened by mysterious diseases among silk-worms. Unsolicited and unassisted pecuniarily, Béchamp at once turned his mind to the problem, not knowing when he did so that it was to bring him into direct rivalry with the man who had been appointed officially, and that, while providing the latter with solutions to the enigma, no gratitude was to be his, but instead the undying hatred and jealousy of Fortune's favourite, Louis Pasteur!