PART ONE

THE MYSTERY OF FERMENTATION

CHAPTER II

A Babel of Theories

Before starting upon any examination of Béchamp's and Pasteur's contributions to the scientific problems of their age, it may be well to revert to the utter confusion of ideas then reigning in the scientific world in regard to the mysteries of life and death and the phenomenon of fermentation. The ensuing chapter can only hope to make clear the utter absence of clarity in regard to these leading questions; and though the work of earlier scientists invariably led up to subsequent discovery, yet in the days when Antoine Béchamp and Louis Pasteur commenced their life-work the understanding of the subject was, as we shall see, in a state of confusion worse confounded.

Three paramount problems then faced the scientific inquirer:

1. What is living matter, this protoplasm, so-called from Greek words meaning "first" and "formed"? Is it a mere chemical compound?

2. How does it come into being? Can it arise spontaneously, or is it always derived from pre-existing life?

3. What causes matter to undergo the change known as "fermentation"?

Among Professor Béchamp's prolific writings quite a history may be found of the confused babel of theories on these subjects.

To start with the first query: there was merely the vague explanation that protoplasm is the living matter from which all kinds of living beings are formed and to the properties of which all are ultimately referred. There was belief in a substance called albumen, best represented by white of egg, which was said to mix with certain mineral and other matters without changing its nature. J. B. Dumas demonstrated that such "albuminoids" comprise not one specific thing, but many different bodies; but the contrary opinion prevailed, and for such substances "protoplasm" was adopted as a convenient term. It was "the physical

basis of life," according to Huxley; but this hardly illumined the difficulty, for thus to pronounce protoplasm to be matter living *per se* was not to explain the mystery of how it was so, or its origin and composition. True, Huxley further declared all living matter more or less to resemble albumen, or white of egg; but this latter was also not understood either by biologists or chemists. Charles Robin regarded it as being of the type of the mucoids, that is to say, as resembling mucus, which latter was so shrouded in mystery that Oken called it *Urschleim* (primordial slime), and the botanist Hugo Mohl identified it with protoplasm, thus dignifying mucus as the physical basis of all things living!

Claude Bernard tried to determine the relation of protoplasm to organisation and life, and combated the general idea that every living body must be morphologically constituted, that is to say, have some structural formation. He argued that protoplasm gave the lie to this belief by its own structural indefiniteness. Charles Robin followed the same view, and gave the name of *"blastème,"* from a Greek word meaning to sprout, to the supposed primordial source of living forms.

This was nothing but the old idea of living matter, whether called protoplasm or *blastème*. A cell, a fibre, a tissue, any anatomical element was regarded as living simply because of its formation by this primordial substance. Organisation was said to be its "most excellent modification." In short, formless matter was supposed to be the source of all organised living forms. In a kind of despair of any experimental demonstration of organisation and life, a name was invented for a hypothetical substance magically alive although structurally deficient. Imagination played more part in such a theory than deduction from tangible evidence. Thus we find that the physician Bichat, who made a name for himself in science before he died in 1802, at the early age of 31, could not accept such an explanation and declared the living parts of a living being to be the organs formed of the tissues.

A great step was gained when Virchow thought he saw the cell in the process of being built up, that is, structured, and thus jumped to the conclusion that it is self-existent and the unit of life, from which proceed all organised forms of developed beings.

But here a difficulty arose, for the cell proved as transitory as any other anatomical element. Thus many scientists returned to the belief in primordial structureless matter, and opinion oscillated between the views held by cellularists and protoplasmists,

as the opposing factions were designated. Utter confusion reigned among the conflicting theories which struggled to explain how a purely chemical compound, or mixture of such compounds, could be regarded as living, and all sorts of powers of modification and transformation were ascribed to it with which we need not concern ourselves.

Instead let us consider the second problem that faced Béchamp and Pasteur when they started work, namely, whether this mysterious living substance, which went by so many names, could arise independently, or whether pre-existing life is always responsible. It is hard to realise nowadays the heated controversy that raged in the past around this perplexing mystery. The opposing camps of thought were mainly divided into the followers of two eighteenth-century priests—Needham, who claimed that heat was sufficient to produce animalculæ from putrescible matter, and Spallanzani, who denied their appearance in hermetically sealed vessels. The first were named Sponteparists from their belief that organised life is in a constant state of emergence from chemical sources, while the second were named Panspermists from their theory of a general diffusion of germs of life, originally brought into being at some primeval epoch.

For the latter view the teaching of Bonnet, following upon that of Buffon, was chiefly responsible; while Buffon's ideas are reminiscent of the ancient system ascribed to Anaxagoras. According to this last the universe was believed to be formed of various elements as numerous as its different substances. Gold was supposed to be formed of particles of gold; a muscle, a bone, a heart, to be formed of particles of muscle, of bone, of heart. Buffon taught that a grain of sea-salt is a cube composed of an infinite number of other cubes, and that there can be no doubt that the primary constituent parts of this salt are also cubes, which are beyond the powers of our eyes and even of our imagination.

This was an experimental fact, says Béchamp,[1] and was the basis of the system of crystallography of Hauy.

Buffon argued in the same strain that "in like manner that we see a cube of sea-salt to be composed of other cubes so we see that an elm is but a composite of other little elms."

Bonnet's ideas[2] were somewhat similar; the central theme of

[1] *Les Microzymas*, p. 30.
[2] See *Ire partie*; *Oeuvres d'Histoire Naturelle de Bonnet*; V. pp. 83-86. Neuchâtel, 1779.

his teaching being the universal diffusion of living germs "capable of development only when they meet with suitable matrices or bodies of the same species fitted to hold them, to cherish them and make them sprout—it is the dissemination or panspermy that, in sowing germs on all sides, makes of the air, the water, the earth and all solid bodies vast and numerous magazines where Nature has deposited her chief riches." He maintained that "the prodigious smallness of the germs prevents them from being attacked by the causes that bring about the dissolution of the mixtures. They enter into the interior of plants and of animals, they even become component parts of them, and when these composites undergo the law of dissolution they issue from them unchanged to float in the air, or in water, or to enter into other organised bodies."

Such was the imaginative teaching with which Bonnet combated the doctrine of spontaneous generation. When it came to practical experimental proof one party professed to demonstrate the origin of living organisms from putrescible matter in sealed vessels; the other party denied any such possibility if air were rigorously excluded; while a pastrycook named Appert put this latter belief to a very practical use and started to preserve fruits and other edibles by this method.

And here we are led to the third conundrum: What causes matter to undergo the change known as fermentation?

It is a puzzle that must have been brought home to many a housewife ignorant of scientific problems. Why should the milk left in the larder at night have turned sour by the morning? Such changes, including the putrefaction that takes place after the death of an organism, were so much of a mystery that the causes were considered occult for a long time. Newton had discoursed of the effect being due to an origin of the same order as catalysis—a process in which a substance called a catalytic agent assists in a chemical reaction but is itself unchanged. The myriads of minute organisms revealed later on by the microscope in fermenting and putrefying matters were at first believed to be mere results of the general process of putrefaction and fermentation.

A new idea was introduced by Cagniard de Latour, who maintained that fermentation is an effect accompanying the growth of the ferment. That is to say, he looked upon the ferment as something living and organised, by which fermentation is rendered a vital act. It was the microscopic study of beer-yeast,

undertaken about the year 1836, which brought him to the opinion that the oval cells he observed were really alive during the production of beer, decomposing sugar into carbonic acid and alcohol. Turpin, the botanist, interpreted this as meaning that the globule of yeast decomposes sugar in the act of nourishing itself. J. B. Dumas maintained the necessity for nitrogenised albuminoid matter, as well as sugar, for food for yeast cells. Schwann, the German, went farthest of all by declaring that all fermentation is induced by living organisms, and undertook experiments to prove these to be airborne. But in spite of other experiments confirming Schwann's work, for a time this teaching was set aside for the view that vegetable and animal matters are able to alter of themselves. For instance, the theory was held that by dissolving cane-sugar in water it changes of itself into grape-sugar, or glucose; or, using technical terms, cane-sugar undergoes inversion spontaneously.[1]

Such, roughly speaking, were scientific ideas at the middle of the nineteenth century, when Antoine Béchamp and Louis Pasteur appeared on the scene with details of their respective experiments. As Pasteur is renowned as the first to have made clear the phenomenon of fermentation, besides being appraised as the one who overthrew the theory of spontaneous generation, let us, instead of taking this on trust, turn to the old French scientific documents and see for ourselves what he had to say in the year 1857.

[1] The usual product of this hydrolysis, or inversion of cane-sugar, is invert-sugar; but, as this was formerly described as grape-sugar, that expression is usually retained here.