The Formation of the Scientific Mind

GASTON BACHELARD

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A Contribution to a Psychoanalysis of Objective Knowledge

GASTON BACHELARD

Introduced, translated and annotated by
Mary McAllester Jones

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Contents

Translator's note

Gaston Bachelard's *The Formation of the Scientific Mind* is his best known book in France, for many years on the school and university syllabus, and this is the first English translation of the work. The range of material Bachelard covers here has faced the translator with a number of challenges, in particular with regard to the seventeenth and eighteenth-century pre-scientific texts he cites. I am very grateful to Bill Ross of Clinamen Press for tracking down some of the original English texts used by Bachelard in their French translations; I am grateful too to the librarians at Birmingham University Library who permitted me to consult Joseph Priestley's own copy of his *History and Present State of Electricity*, a book which Bachelard clearly knows well in translation. Thanks to them, I have been able to cite Boerhaave, MacBride, Hitchcock, and Priestley in the original English. I have, where necessary, amended and corrected Bachelard's footnotes; it has not always been possible however to remedy his omissions, despite much effort, the clues he gives regarding his sources proving at times too slender. Full details of a work cited are given in a note when Bachelard first refers to it; when subsequent references are made, readers who wish to can look back to these details by checking the author's name in the Index; when Bachelard draws on several works by the same author, these are specified at each reference.

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first appeared in my book *Gaston Bachelard, Subversive Humanist*, published by them in 1991. Some small amendments have been made here to those original translations. I would also like to thank very sincerely all those I have worked with at Clinamen Press for their unfailing helpfulness, patience, and professionalism.

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Mary McAllester Jones

Introduction

Published in 1938, *The Formation of the Scientific Mind* seems from its title to break with Bachelard's previous work which, in the decade following the appearance of his first book in 1928, had been chiefly concerned with the epistemology of post-Einsteinian science, with what he came to call the 'new scientific mind'. 'Formation' does not though signal a shift in interest to the history of how the scientific mind was formed: Bachelard makes it clear from the beginning that he writes as an epistemologist and not as a historian, carefully demarcating these two activities. 'Historians of science', he says, 'have to take ideas as facts. Epistemologists have to take facts as ideas and place them within a system of thought. A fact that a whole era had misunderstood remains a *fact* in historians' eyes. For epistemologists however, it is an *obstacle*, a counter-thought' (27). Bachelard stresses that epistemology is normative, dealing with ideas that 'have had an intellectual destiny' (22) and working from 'the standpoint of developed reason, for it is only now that we can really judge the errors of the mind's past' (27). As an epistemologist, he is concerned therefore with the forming of the scientific mind. This active sense of 'formation' in Bachelard's use of the word is very clear when he argues that 'the scientific mind must be formed by being reformed' (33), implying that far from being complete and achieved, the formation of the scientific mind is an ongoing process. It is clear too when he discusses teaching – 'formation' in French also means teaching or training – a discussion he not only pursues throughout this book but with which he chooses to conclude it, affirming that 'the principle of *continued culture* is moreover at the root of modern scientific culture … There is science only if schooling is permanent' (249).

There is another strand in this active sense of 'formation', for twice Bachelard uses the phrase 'psychologically formative' to describe modern

scientific thought (103, 246). This can be set alongside two key statements. Early in the book, Bachelard offers the following definition of human beings: 'Through the mental revolutions that scientific invention requires, humankind becomes a mutating species, or to put it better still, a species that needs to mutate, that suffers if it does not change. Mentally, humans need to need' (26). Then in his final chapter, he clarifies this notion of a 'mutating species' when he writes that 'An objective discovery is at once a subjective rectification. If the object teaches me, then it modifies me. I ask that the chief benefit the object brings should be an intellectual modification' (246). Bachelard's use of 'I' shows his commitment to the idea of intellectual modification which, like those of mental revolution and mutation, helps us to understand his view of modern scientific thought as 'psychologically formative'. We see then that Bachelard is also concerned here with the formation of the mind by modern science. The word 'formation' is a rich one therefore and although Bachelard came to regard his title as ill-chosen[1] – perhaps because of the tendency for this book to be seen as history, as an often entertaining narrative of human error and folly – it is also very apt, its plurality and variation obliging readers to ask questions, to have the 'sense of the problem' that for Bachelard 'marks out the true scientific mind' (25).

The 'true scientific mind' is precarious, at risk because of what Bachelard calls the mind's 'conservative instinct', to which he believes the 'formative instinct' inevitably yields (25), and it is this notion of the mind's instincts that underlines the difference between this book and its predecessors. In *The New Scientific Spirit*,[2] Bachelard had referred to scientists 'passionately pursuing a life devoid of passion'. Four years later, this seems too simple, aware as he now is of the instincts and values hindering the development of the intellectual life. 'Science calls a world into being', he had written in 1934, 'not through some magic force, immanent in reality, but rather through a rational force, immanent in the mind'. Now though his confidence in this rational force is shaken, for he has understood 'all the emotions involved in the use of reason ... the range of values associated with the rational emotion' (243). In his first book, his *Essai sur la connaissance approchée* (1928), Bachelard had explained his reasons for considering knowledge 'as it flows along, far from its origin in the senses, at the point at which it has become intimately involved with reflection', adding that:

> The mind that knows must of necessity have a past. The past, the antecedent, provide ... the tools with which we can arrive at explanations. Besides, is not the living mind distinguished from the inert object by the riches that lie ever at our disposal, which memory uses in accordance with the situations that arise, so that our actions may be adjusted to fit new circumstances? It is this inflection of the mind's past as a result of the attractive force exerted by an inexhaustible reality that constitutes the dynamic element of knowledge.[3]

Ten years later, Bachelard has realised that the senses are not so easily relegated, and that the mind's past can obstruct rather than advance knowledge. He is now convinced that '*the problem of scientific knowledge must be posed in terms of obstacles*', epistemological obstacles 'at the very heart of the act of cognition' (24). They require what he terms 'cognito-affective control' (29) and psychoanalysis.

Psychoanalysis may well seem an odd concept to use in a book concerned with epistemology, especially when we remember that in French this is defined as the study of scientific knowledge. Psychoanalysis is surely to do with irrationality, so how can reason and objective knowledge be psychoanalysed? Early in the book, Bachelard explicitly links psychoanalysis to philosophy of science, arguing that 'the task of the philosophy of science is very clear: it is to psychoanalyse interest, to destroy all utilitarianism, however disguised its form and lofty the status it claims, and to turn the mind from the real to the artificial, from the natural to the human, from representation to abstraction' (21). This suggests that for Bachelard, the therapeutic aspect of psychoanalysis is paramount: psychoanalysing objective knowledge means ridding it of everything that impedes its progress, whether affective interests or everyday, utilitarian knowledge, so restoring it to health. His therapeutic aim can be seen again, a few pages later, when he writes that 'all scientific culture must begin with an intellectual and emotional catharsis' (29). This refers to the analytical method Freud took over from Breuer, which he initially called 'Breuer's cathartic method', Bachelard's association of Freud with catharsis being clear in *The Dialectic of Duration* (1936) when he comments on Freud's 'cathartic method'.[4] Moreover, in *Les Intuitions atomistiques* (1933) he had chosen to describe his own work in terms of 'a cathartic task'.[5] Indeed, looking back to *The Formation of the Scientific Mind* in a 1939 conference paper entitled 'La Psychanalyse de la connaissance objective', he says that in examining the formation of the scientific mind, he had 'recognised the need for a cathartic intellectual education'.[6] This underlying idea of a therapeutic intention helps to explain why Bachelard sees psychoanalysis as relevant to epistemology: with its guiding concepts of health and disease – concepts that Bachelard exploits here – psychoanalysis is also normative.

Bachelard's knowledge of psychoanalysis is markedly more precise in

The Formation of the Scientific Mind than in his previous books. He had referred to psychoanalysis for the first time in *The New Scientific Spirit*, briefly mentioning the concepts of the unconscious, of repression and sublimation; his first reference to Freud by name was made in a review published the same year.[7] While Bachelard seems at ease with these concepts, there is no indication that he has read Freud or commentaries on psychoanalysis. This is hardly surprising given the lack of work on Freud then available in French: Freud had not been translated into French until the 1920s, suggesting resistance to the ideas of psychoanalysis in France, which is borne out by the fact that at the sixth International Psychoanalytical Congress in September 1920, among the sixty-two members Ernest Jones lists as present none came from France.[8] Even more tellingly, Raymond de Saussure's book *La Méthode psychanalytique* was forbidden publication in France in 1923. While the foundation of the French *Société de psychanalyse* in 1926 and of the *Revue Française de Psychanalyse* the following year shows growing acceptance of psychoanalytical theory there, this is largely restricted to a medical circle. It is surely symptomatic that the first books in France to apply a psychoanalytical approach to the study of literature – René Laforgue's study of Baudelaire in 1931 and Marie Bonaparte's of Poe in 1933 – were written by doctors, in what Charles Mauron calls 'a purely medical spirit'.[9] Small wonder then that Bachelard's knowledge of psychoanalysis is initially pretty limited. Then in *The Formation of the Scientific Mind*, we find him quoting René Allendy (a leading French psychoanalyst), Ernest Jones, and Oskar Pfister (a close friend and supporter of Freud for many years), referring to Freud and also to Karl Abraham, Havelock Ellis, Otto Rank, and Herbert Silberer.[10] Bachelard is said to have owed his increased knowledge of psychoanalysis to Juliette Boutonier, a colleague and close friend at the University of Dijon since 1930, whose professional interest was in child psychology, with whom he not only talked at length but also attended case studies of disturbed patients.[11] Bachelard's desire to discover more about psychoanalysis, under a friend's guidance, can be explained in terms of his zest for knowledge.[12] Sheer intellectual curiosity does not though seem sufficient explanation for his own engagement with it in a psychoanalysis of objective knowledge.

The normative aspect of psychoanalysis clearly struck a chord with Bachelard as an epistemologist. In particular, it seems to have suggested to him a way of dealing with the aberrations of what he calls pre-scientific thought. Bachelard had for some years been reading and making notes on pre-scientific texts – the municipal library in Dijon has a good collection of these – but without really using that knowledge. His notes constitute a 'chamber of horrors', as he puts it (31), a record of what he variously describes here

as absurd, wild, foolish, and irrational ideas. And he could have left it at that. Yet as he frequently points out, these ideas were tenacious, widely accepted, and moreover often produced by intelligent people, by good observers and experimenters. What strikes him is the difficulty of forming the scientific mind. Bacon, for instance, the 'creator of modern empiricism' can be seen 'reasoning' in a manner characteristic of primitive mentality (68), and Descartes and Benjamin Franklin are among the many who used sponge as an explanatory image in their thinking (86). Technical progress such as the invention of the microscope did not guarantee increased objective knowledge: instead, as Bachelard shows, for some minds the microscope reinforced preconceptions (162). Nor is scientific progress achieved once and for all: Bachelard gives a number of examples taken from eighteenth-century texts of resistance to Newton's 'mathematisation of experience', not because of disagreement on mathematical grounds but due to the interference of what he sums up as 'familiar images' (224). Bachelard's examples are for the most part taken from eighteenth-century texts, a few being from seventeenth-century writers. The majority are from those we might dismiss as 'bad writers' but who often enjoyed considerable success (38), and Bachelard makes the point that 'what characterises the pre-scientific period is in fact the great influence exercised by second-rate writers' (88). The 'age of reason' and the 'age of enlightenment' are, despite these labels, marked by unreason. Educated, wealthy members of 'polite society', as he calls it, are shown to be besotted with electricity, playing what seem to us mere party-games with its phenomena. Moreover, among 'second-rate writers' are aristocrats, clergymen, and doctors, all educated people. And yet they variously display symptoms of 'disturbed minds'. This last phrase, used following a particularly odd quotation from a writer convinced of the curative properties of the blood, flesh, liver, fat, skin, and excrement of cats (97), suggests how psychoanalysis has given Bachelard a fresh perspective on the mass of pre-scientific material he has gathered. It casts new light on the errors found there: manifestly neither mathematical nor empirical, these are now seen as due to some kind of mental disturbance. He could have just regarded them as entertaining aberrations, light relief from the serious business of the 'new scientific mind'. Psychoanalysis makes him take them seriously, as evidence of unreason which, with its constellations of values, instincts, and affective interests, results in blockages impeding the formation of the scientific mind.

In Bachelard's psychoanalysis of objective knowledge these blockages are termed epistemological obstacles, which he defines as causes of inertia arising in the act of cognition (24). It is an original idea and as he examines these obstacles in the course of the book, Bachelard is clearly fascinated by

what they reveal about the 'dark areas' of the mind (19). His aim though is not to analyse but to psychoanalyse, that is to say to rid the scientific mind of these obstacles, which have to be surmounted: 'all scientific culture must begin with an intellectual and emotional catharsis', he argues, 'we must put scientific culture on the alert so that it is always ready to move, replacing closed, static knowledge with knowledge that is open and dynamic, dialectising all experimental variables, giving in short to reason reasons for developing' (29). Bachelard's psychoanalysis of reason presupposes a conception of healthy reason, a norm of scientific thought, and in effect serves an epistemology. This point is underlined by his references to 'conceptual sclerosis', to 'mutilated' thought and experiment, and by his frequent use of 'healthy', in phrases such as 'healthy methods', 'healthy approximations', 'healthy abstraction'. Odd and intrusive as this word 'healthy' may at first appear, it is in fact central to Bachelard's project, making its normative aspect plain. Surely it is too late though to restore sick pre-scientific minds to health? Yes of course it is, but that is not the point. The point is that what prevented them from being scientific minds can still disturb the thinking of modern scientists: 'Even in a clear mind', Bachelard argues early in the book, 'there are dark areas, caverns still haunted by shades, and traces of the old remain in our new ways of thinking. The eighteenth century still lives secretly within us and may – alas – return' (19). He goes on to reinforce this: 'In each scientific mind's individual formation', there is 'a necessary passage' through what he calls the three stages of the scientific mind, the concrete, the concrete-abstract, and the abstract (20), necessary in the sense of obligatory, not automatic. For Bachelard, forming the scientific mind requires bringing these stages to consciousness, actively displacing their different affective interests and surmounting the obstacles they present to scientific thought. Moreover, his classroom experience as a science teacher has shown him the eighteenth century still living – not always secretly – in his young pupils' minds. As moderns, we have no cause for complacency: pre-scientific patterns of thought persist, and the epistemological obstacles seen there remain hazards to the scientific mind.

Chapter by chapter, Bachelard examines the epistemological obstacles to objective thought, showing the pitfalls of empiricism and the difficulty of achieving objectivity. These obstacles arise in the act of cognition because the mind is not *tabula rasa*: 'Even when it first approaches scientific knowledge', he argues, 'the mind is never young. It is very old, in fact, as old as its prejudices (24-5). This is not just a matter of ordinary, everyday knowledge – immediate knowledge – blocking scientific thought but rather of the interference of values ascribed to that knowledge by human beings. The notion of

immediate knowledge is misleading, in Bachelard's view: 'what is most immediate in primary experience is indeed ourselves, our hidden passions and unconscious ideas' (54). So-called immediate knowledge is mediated by human values, which paradoxically we do not know. Thus for Bachelard, the human being constitutes the chief obstacle to scientific thought; human values, he argues, are fundamental to empirical thought, not something added to it later on. While there are many strands in this valorisation, he sees it as stemming from the senses: 'it must be recognised that empirical knowledge ... engages sentient human beings via all aspects of their sensibility. When empirical knowledge is rationalised, we can never be sure that primitive sense values are not coefficients attaching themselves to reasons' (26). This is at the heart of Bachelard's thinking here.

Human sensibility is regarded as involving much more than the senses – sight, touch, smell, hearing, taste – that give empirical knowledge. Bachelard shows how values interfere in sensory knowledge, arguing that valorisation is direct and immediate, constituted by 'the passionate espousal of primary ideas, ideas that find but pretexts in the objective world' (61). The primary experience he describes as the first epistemological obstacle is not just of everyday life but of feelings about it, feelings such as the fear and wonderment so clear in pre-scientific texts. These texts are also marked at times by social feelings, by writers' feelings about their social status: Buffon serves as an example here, his sense of his own social functions intervening, Bachelard argues, in his observations of nature (53-4). Moral feelings are also part of primary experience, as Bachelard shows in his discussion of alchemy. Childhood feelings are engaged here too: our first knowledge is described as a '*childhood treasure*' (49), this phrase suggesting both the emotional value placed on first convictions and the important idea of primary experience as a loved possession. The feeling of having, as Bachelard calls it, is a key element in human sensibility, making realism and substantialism powerful epistemological obstacles. Reality and substance are valued as possessions, the sense of internal possession having a primary role: in his chapter on the myth of digestion, Bachelard shows how feelings about digestion – or better, feelings of digestion – are valorised in some pre-scientific texts to the extent that 'reality is initially a food' (172). Three chapters – Six, Seven, and Nine – explore this valorisation of reality and substance, showing how love of reality obstructs knowledge of reality. Linked to this feeling of having is that of becoming. Humans have life – life is described here as 'a clear and general datum' (154) – and feel life as becoming, that is to say as growth, death, sexuality, mystery, and time. This feeling of becoming intrudes in objective knowledge since it leads to the valorisation of all life, of all that is considered

natural and biological, so that the vegetable kingdom is valued above the animal and mineral, germ and seed for instance being privileged, explanatory images. While these values are discussed in Chapters Eight and Ten in particular, they also come into other chapters, for the feelings of having and becoming are not easily separated. Indeed, as he concludes this book, Bachelard emphasises that the scientific mind must put an end to 'vital interests', using this phrase to sum up the epistemological obstacles he has discussed: life is the first value, the first idea, passionately espoused by humans who know it as an immediate possession which, because it is possession of becoming, is precarious and therefore greatly valued.

In Bachelard's view, this unconscious valorisation prevents the pre-scientific mind from achieving the freedom to judge; it must be brought to consciousness and removed – 'psychoanalysed', as he puts it – in order for the scientific mind to be formed. He discusses the mental processes and experimental methods of pre-scientists, showing how these are shaped by such valorisation. Generalisation, over-determination, and antithetical valorisation, together with fondness for both variety and repetition, for metaphors and images, grandiloquence and verbosity are all seen to typify pre-scientific thinking. They make for a kind of logic – an 'irrational reason' – that allows us to make sense of the curious examples he quotes. More important though, they are demarcated from scientific thought. Bachelard remarks several times on the discontinuity of eighteenth and nineteenth-century thought, no eighteenth-century observation for example having given rise to a nineteenth-century technique (78). There is nothing automatic however about this epistemological break: the scientific mind does not spring fully formed from the heads of those born after the eighteenth century has ended. It is not just schoolchildren who go on thinking pre-scientifically but in Bachelard's experience, so do teachers and the writers of school textbooks, with their love of inappropriate detail (214); so too, he considers, do advertisers and consumers (118) and also – tarring them with the same brush – philosophers. Philosophers are always criticised by Bachelard for ignoring the lessons of modern science, this criticism being made even more pointed here by his argument that in the emphasis they place on generalisation in science they are in fact thinking pre-scientifically. He regards generalisation as having its source in values, in that of usefulness especially (31), his reference here to pragmatism suggesting that he has one particular philosopher in mind, Henri Bergson.

From his first work onwards, Bachelard's opposition to Bergson is clear.[13] What he rejects is first and foremost Bergson's conception of understanding and intellect as geared to action on the world, as relative to the practical requirements of everyday life, the world being understood only in

terms of its usefulness to human beings. Thus, Bergson sees the scientist as *homo faber*, governed by pragmatic considerations, and science as part of everyday life. Modern science makes these ideas untenable, in Bachelard's view, and so his long polemic with Bergson begins, leading him to develop, against Bergson, his own conceptions of consciousness, time, and human beings. Here, this polemic is implicit, conducted through a critique not just of pragmatism but of intuition and the valorisation of the inner life, of life regarded as superior to the mind, conducted too through references to *homo faber* and also to duration and time. At the beginning of Chapter Ten, Bachelard observes that 'Gratuitous time, time that has been emptied, the time of a philosophy of repose, is time that has been psychoanalysed. We shall be working on this in another book' (185). This is a surprising and important observation, surprising because the book referred to in the future tense is *The Dialectic of Duration*, published in fact two years previously in 1936, and important in that it shows him not just at work on *The Formation of the Scientific Mind* well before 1938 but thinking out these two books concurrently. The fact that it is written, in part at least, not after but while reflecting on a conception of time opposed to Bergson's should lead us to consider it from this same perspective, as part of Bachelard's polemic with a philosopher whose scientific mind he considered to have remained unformed.

Bachelard regarded himself not as a philosopher but as a philosopher of science, learning from modern science about the possibilities of the scientific mind and with it, of the human mind. In *The New Scientific Spirit*, he had suggested – against Bergson – the idea of the human being as *homo aleator*, *homo mathematicus*, that is to say as exploring possibility through mathematics. Now though his concern is with objective, empirical knowledge, with forming the scientific mind against everyday knowledge and experience, in many ways more difficult because of the values, interests, and feelings it involves. Ridding the mind of these interests, of utilitarianism in particular, is therefore in Bachelard's view the first thing that philosophers of science must do, no progress being made without this (21). Secondly, they must 'turn the mind from the real to the artificial': whereas the pre-scientific mind possesses reality, the scientific mind constructs and reconstructs it, and in doing so is itself constantly reformed. They must also turn the mind 'from the natural to the human'. Given that the human being is presented as an obstacle to scientific knowledge, this may seem odd; if however we see that what constitutes this particular obstacle is a view of the human as natural, there is no contradiction. Implicit in Bachelard's phrase is the opposition between life and the mind, thus allowing a new perspective on the second task, so that the artificial is more plainly a human, mental construction.

Bachelard stresses this in a number of ways, in particular by referring to the 'inventive' empiricism, the 'active', 'thought' empiricism of modern science, in opposition to the passively recorded, found empiricism of pre-science. Linked to this is his conception of the discursive, dialectical objectivity of modern science, explained throughout the book and perhaps most strikingly in Chapter Eleven when he shows how objectivity is affirmed 'within measurement as a discursive method' (213). Indeed, Bachelard argues that 'for the scientific mind every phenomenon is a moment in theoretical thought, a stage of discursive thought, a result that has been *prepared*' (108), thus identifying the discursive and the theoretical. This would seem to contradict the idea he also expresses here of the polemic of reason and reality, rationalism and empiricism, discursive thought consisting therefore of this polemic. In shifting the emphasis to reason, he is in fact stressing that for the scientific mind, it is reason that constructs reality. The '*vector of abstraction*' (26), as he calls it, is essential for the progress of modern science. For Bachelard, abstract thought is mathematical thought: 'we ourselves believe', he says, 'that mathematical thought forms the basis of physical explanation and that the conditions of abstract thought are from now on inseparable from those of scientific experiment' (229). The last aspect of the task facing philosophers of science is consequently the key to all the rest, both essential and difficult: in turning the mind 'from representation to abstraction', they teach it to re-form.

Teachers form the scientific mind, for good or ill, and Bachelard's critique of science teaching is vigorous here. He provides many examples from his own classroom experience of the persistence of pre-scientific ways of thinking not just in modern children but in teachers and in those who determine educational policy. In stressing the natural and the empirical, science teachers fail to understand the scientific mind and he is scathing about reforms introduced into secondary-school science teaching: he believes that in diminishing the difficulty of physics problems, 'such reforms misunderstand the real meaning of the scientific mind. Total ignorance is preferable to knowledge that has lost its fundamental principle' (49). But what is this fundamental principle? Bachelard explains how he sees it when, in his final chapter, he writes that: 'teachers put lessons in the place of discovery. Teaching about the discoveries that have been made throughout the history of science is an excellent way of combating the intellectual sloth that will slowly stifle our sense of mental newness. If children are to learn to invent, it is desirable that they should be given the feeling that they themselves could have made discoveries' (245). The key phrase here is 'our sense of mental newness', for it shows that Bachelard is referring to a mental rather than an empirical process of discovery. He was strongly opposed to teaching methods based on the

principle of 'look and learn', highly critical in an article published a few years earlier[14] of what he termed 'the Education Ministry's view of experimental science: weigh, measure, and count; be wary of abstraction and of rules; attach young minds to the concrete, to facts'. This kind of teaching is no longer appropriate, he argues, in an age when discoveries are made almost entirely by mathematics. Bachelard returns to this here, stressing for example the need to teach not the results of science but the mental route to those results, and suggesting exercises in discursive thought to help guide pupils' minds 'into the paths of abstraction' (234). Scientific abstraction is described by Bachelard as 'healthy' and 'dynamic' (18) and – even more strikingly – as a 'duty' (21), all of these value-laden words which point to an underlying view of human beings.

Bachelard's conception of human society and human beings is stated, boldly and idiosyncratically, as he concludes this book. His final paragraph sums up what he has learned about human beings from psychoanalysis – about their psychic dynamism in particular – and at the same time suggests what will eventually lead him to reject it, his emphasis being firmly on the mind. He did not, as it turned out, continue with his 'psychoanalysis of objective knowledge': although *The Psychoanalysis of Fire*,[15] also published in 1938, was meant to develop the arguments of *The Formation of the Scientific Mind* it became something very different, for in writing it Bachelard came to understand the imagination not as an obstacle but as an essential aspect of psychic dynamism. Poetic imagination became his focus over the next decade, with the publication of four books on images of water, air, and earth.[16] While psychoanalytical ideas continued to stimulate him, he would always adapt them in terms of his own conception of human beings; in the end however, in his later work on both epistemology and poetry[17] he came to prefer phenomenology as more consonant with his long-held conviction that 'it is thought that rules our being'.[18] Initially though psychoanalysis seemed to offer a way of ensuring the rule of thought and with it, the health of our being. Initially too, the psychoanalysis of the scientific mind seemed to him a way of countering the harm done by teaching, as he explains in 'La Psychanalyse de la connaissance objective'. Critics might wish him to have been more modest and called his book 'a pedagogy of the scientific mind', he says, but pedagogy in this context rests on ideas he opposes, ideas such as authority and adaptation to a particular society, and above all on what he terms 'a closed epistemology'. Contrary to this, he argues, psychoanalysing the scientific mind means opening it, making it conscious of 'an open epistemology'.

Bachelard breaks with this view of pedagogy, envisaging as he con-

cludes this book a time when 'society will be made for school, not school for society', thus reversing the popular view that 'school is made for society'. The idea of the social purpose of education prevailed in Bachelard's day, as a contemporary primary-school textbook demonstrates[19]: in it, a journey through France serves to teach two children to love and do their duty towards their country; everything they learn about as they travel, including scientific discoveries, is made to serve a patriotic end, Fresnel for example being valued for improving lighthouse lamps to the glory and safety of France. In rejecting this kind of thinking, Bachelard was being intentionally provocative. He was provocative too in his references to morality and duty, as comparison with the same textbook shows: subtitled 'Duty and Country', it turns everything encountered into a moral lesson and concludes that 'what constitutes the glory, honour, wealth, and strength of France is her children's moral value', spelt out as obedience, hard work, and love of family and country. How odd Bachelard's reference to the duty of abstraction must have seemed! He is not though being gratuitously provocative, but raising fundamental questions with regard to society and human beings.

If school is made for society, what is society for? If we say it is for the good of humans, what is that good? And if society is made for school, what is school for? While here the answer seems much easier – we go to school for our education, our 'formation' – it makes us ask what education is for. If it is for its own sake, as Bachelard believes, then why? What is it about human beings that makes permanent schooling necessary? His references to abstraction as a duty and as healthy provide the clue and bring us back to his 'psychoanalysis of objective knowledge'. Bachelard has shown human beings as obstacles to objective knowledge, as burdened with misplaced affectivity, immobilised and unhealthy. They are also a 'mutating species', needing to mutate, suffering if they do not change, healthy therefore if they follow the mental revolutions of science. Abstraction is a duty because in breaking with the concrete, it frees and dynamises the mind, ensuring this healthy mutation. Thus when Bachelard refers at the end of Chapter One to the 'moralisation of science' this does not imply a view of its social responsibilities but, as the context shows, a conception of human beings, a conviction that 'those who follow the laws of the world are already submitting to a great destiny'. Yet this would seem to exclude non-scientists, as does the emphasis he places on mathematics in the closing sections of Chapter Twelve. For Bachelard though, non-scientists can also 'follow the laws of the world' through reading science; struggling to understand the difficult ideas of modern science, they too can experience the will to know, they too can learn to reflect on reflection, to think *against* the brain, as he puts it (248).[20] In this sense then,

scientific thought is psychologically formative for all who try to learn its lessons. The school of science – formation by the scientific mind – helps humans to fulfil their destiny, their dynamic, open intellectuality. Bachelard's views remain provocative, for science and education continue to be seen as having a social, practical purpose, as contributing to what Lyotard in *The Postmodern Condition* has called the 'performativity' of the social system. With its argument that this leads to closed minds and mutilated human beings, Bachelard's book still raises uncomfortable questions.[21]

Mary McAllester Jones

NOTES

1 Bachelard acknowledged this in an interview with Alexandre Aspel in 1957, quoted by C. G. Christofides in 'Bachelard's Aesthetics', *Journal of Aesthetics and Art Criticism*, 20:3 (1962), 267.

2 *The New Scientific Spirit*, trans. Arthur Goldhammer (Boston: Beacon Press, 1984) is the English translation of *Le Nouvel Esprit scientifique* (Paris: Alcan, 1934), now published by Presses Universitaires de France. My translations are used here as throughout this Introduction; information is given whenever an English translation is available of a work by Bachelard to which reference is made.

3 *Essai sur la connaissance approchée* (Paris: Vrin, 1928). This book was originally Bachelard's principal doctoral thesis (1927); translated extracts from it are included in Mary McAllester Jones, *Gaston Bachelard, Subversive Humanist. Texts and Readings* (Madison: University of Wisconsin Press, 1991).

4 *The Dialectic of Duration*, trans. Mary McAllester Jones (Manchester: Clinamen Press, 2000), 147; this is the English translation of *La Dialectique de la durée* (Paris: Boivin, 1936), now published by Presses Universitaires de France.

5 *Les Intuitions atomistiques* (Paris: Boivin, 1933); now published by Vrin.

6 Published in *Annales de l'É cole des Hautes Études de Gand* (1939), 3.

7 In 'Pensée et Langage (Revue critique)', *Revue de Synthèse* (1934).

8 Ernest Jones, *The Life and Work of Sigmund Freud*, ed. Lionel Trilling and Steven Marcus (London: Penguin Books, 1967), 496.

9 Charles Mauron, *Des Métaphores obsédantes au mythe personnel. Introduction à la Psychocritique* (Paris, Corti: 1962), 18; see also Marie-Louise Gouhier, 'Bachelard et la psychanalyse: la rencontre' in *Bachelard. Colloque de Cerisy* (Paris: Union Générale d'Éditions, 1974), 142; she provides useful information about Bachelard's introduction to psychoanalytical ideas.

10 The lack of reference to Jung here is striking given that Bachelard makes extensive use of Jungian concepts in his books on poetic images. Christofides states that

Bachelard told Alexandre Aspel that he had 'received Jung too late'; see C. G. Christofides, 'Gaston Bachelard and the Imagination of Matter', *Revue Internationale de Philosophie*, 17 (1963), 486. Bachelard refers however to Jungian concepts and expresses his admiration for Jung in *The Psychoanalysis of Fire* also published in 1938 (see note 15), which suggests that *The Formation of the Scientific Mind* was largely worked out before this date.

11 Juliette Boutonier (later Favez-Boutonier) was a colleague of Bachelard's in the Department of Philosophy at the University of Dijon (in France, psychology was then regarded as a branch of philosophy), later moving to Paris; she practised as a child psychotherapist and was influential in the development of psychoanalysis in France. Marie-Louise Gouhier refers to his friendship with Juliette Boutonier, see above, note 9. Bachelard took up the Chair of Philosophy at the University of Dijon in 1930, remaining there until his appointment in 1940 to the Chair of the History and Philosophy of Science at the Sorbonne; he retired from this at the age of seventy in 1954. From 1919 to 1930, he taught physics and chemistry and then philosophy too (after obtaining his *agrégation* in philosophy in 1922), at secondary-school level in Bar-sur-Aube, the small town in Champagne where he was born.

12 Bachelard stresses the importance of the 'will to know' in human beings, and his own life demonstrates this. After secondary school, he worked for the postal service, eventually studying for his *licence* in mathematics – which he obtained in 1912, at the age of 28 – while working as a postal agent in Paris. While on study-leave in 1913-14, he prepared for the competitive examination for engineering students in telegraphy, in which he came third, so failing to obtain one of the two places available. After serving in the trenches for 38 months in the First World War, he began his teaching career in 1919, studying for his *licence* in philosophy, which he obtained at the age of 36 after one year of study in 1920, the year when his wife died, leaving him with a young daughter to bring up alone. In 1922, he obtained his *agrégation* in philosophy, and then in 1927, aged 43, his *doctorat-ès-lettres* at the Sorbonne.

13 Cristina Chimisso has discussed the relations between Bachelard and Bergson in her Introduction to *The Dialectic of Duration*: see above, note 4. I have also discussed these in *Gaston Bachelard Subversive Humanist* (see note 3), and in a number of articles, in particular in 'Bachelard contre Bergson: vers une pensée de la différence', in *Gaston Bachelard, l'homme du poème et du théorème* (Dijon: Éditions Universitaires de Dijon, 1986).

14 'Noumène et microphysique', *Recherches philosophiques* (1931-32); this article is included in a posthumously published collection of articles by Bachelard, *Études* (Paris: Vrin, 1970).

15 *The Psychoanalysis of Fire*, trans. Alan C. M. Ross (Boston: Beacon Press, 1964; London: Routledge and Kegan Paul, 1964) is the English translation of *La Psychanalyse du feu* (Paris: Gallimard, 1938).

16 *Water and Dreams*, trans. Edith Farrell (Dallas: The Dallas Institute of Humanities and Culture Publications, 1983); *Air and Dreams*, trans Edith and Frederick Farrell (Dallas: The Dallas Institute of Humanities and Culture Publications, 1988); *Earth and Reveries of Will*, trans. Kenneth Haltman (Dallas: The Dallas Institute of Humanities and Culture Publications, 2002): these are the English translations of *L'Eau et les rêves* (Paris: Corti, 1942), *L'Air et les songes* (Paris: Corti, 1943), and *La Terre et les rêveries de la volonté* (Paris: Corti, 1948). The final volume in this series *La Terre et les rêveries du repos* (Paris: Corti, 1948) has not yet been translated. In addition to this series, Bachelard published in 1939 a book on the poetry of Lautréamont; for the English translation, see *Lautréamont*, trans. Robert Duprée (Dallas: The Dallas Institute of Humanities and Culture Publications, 1984).

17 On epistemology: *Le Rationalisme appliqué* (Paris: Presses Universitaires de France, 1949); *L'Activité rationaliste de la physique contemporaine* (Paris: Presses Universitaires de France, 1951); *Le Matérialisme rationnel* (Paris: Presses Universitaires de France, 1953). On poetry: *The Poetics of Space*, trans. Maria Jolas (New York: Orion Press, 1964; Boston, Beacon Press, 1969); *The Poetics of Reverie*, trans. Daniel Russell (New York: Orion Press, 1969; Boston, Beacon Press, 1971); *The Flame of a Candle*, trans. Joni Caldwell (Dallas: The Dallas Institute of Humanities and Culture Publications, 1988); these are the English translations of *La Poétique de l'espace* (Paris: Presses Universitaires de France, 1957), *La Poétique de la rêverie* (Paris: Presses Universitaires de France, 1960), and *La Flamme d'une chandelle* (Paris: Presses Universitaires de France, 1961).

18 *L'Intuition de l'instant* (Paris: Stock, 1932).

19 G. Bruno, *Le Tour de la France par deux enfants* (Paris: Editions Belin); Bruno was a pseudonym adopted by Augustine Fouillée. First published in 1877, this book ran into hundreds of editions and has been described as the most successful schoolbook ever; a facsimile edition was published to mark the book's centenary. Aimed at 10-11 year-olds, it was written in the aftermath of the humiliating defeat of France by Prussia in 1871, and the consequent loss of Alsace and Lorraine, hence the book's patriotic tone; the two children – orphans – escape from their native Lorraine, then in German hands, hoping to find a relative in Marseille.

20 In *The New Scientific Spirit* (Chapter 4), Bachelard describes the 'psychological benefit' of reading Heisenberg; having to grasp the paradoxes of wave mechanics and the dialectical relationship of matter and energy is, he says, 'excellent mental hygiene'.

21 The following, books are available on Bachelard in English: Cristina Chimisso, *Surrationalism and its Obstacles: Science and Morality in the Philosophy of Gaston Bachelard* (Amsterdam: Harwood Academic Publications, 2000); Colette Gaudin (trans.), *On Poetic Imagination and Reverie: Selections from the Work of Gaston Bachelard* (Indianapolis: Bobbs-Merrill, 1971); Mary McAllester (ed.), *The Philoso-*

phy and Poetics of Gaston Bachelard (Washington: Centre for Advanced Research in Phenomenology and University Press of America, 1989); Mary McAllester Jones, *Gaston Bachelard, Subversive Humanist. Texts and Readings* (Madison: University of Wisconsin Press, 1991); Roch C. Smith, *Gaston Bachelard* (Boston: Twayne, 1982); Mary Tiles, *Bachelard: Science and Objectivity* (Cambridge: Cambridge University Press, 1984).

Foreword

The scientific mind is first seen clearly and incontrovertibly when it makes representation geometrical, that is to say when it delineates phenomena and puts an experience's decisive events into an ordered series. This indeed is how we arrive at *figured quantity*, halfway between the concrete and the abstract in an intermediate zone where the mind aspires to reconcile mathematics and experience, laws and facts. Yet while such geometrisation seemed to have often been achieved – whether following the success of Cartesianism or of Newtonian mechanics or again with Fresnel's optics – in the end it is always shown to be in some way deficient. In most fields, we are sooner or later compelled to note that this first geometrical representation, based on a *naive realism of spatial properties*, involves conformities which are more hidden and topological laws which are less clearly dependent on immediately apparent metrical relations. In short, we note that essential connections are involved here which go deeper than those of familiar geometrical representation. We gradually feel the need to work *beneath* space, so to speak, at the level of those essential relations upholding both space and phenomena. Scientific thought is thus drawn towards 'constructions' that are more metaphorical than real, towards 'configuration spaces' of which perceptible space is, after all, only one poor example. The role of mathematics in contemporary physics therefore goes far beyond simple geometrical description. Mathematism is not descriptive but formative. The science of reality is no longer content with the phenomenological *how*: the mathematical *why* is what it seeks.

Moreover, since the concrete already accepts geometrical form and is correctly analysed by the abstract, why should we not agree to make *abstraction* the normal and productive approach of the scientific mind? In point of fact, if we reflect on the development of the scientific mind, we very soon

detect a momentum going from the more or less visual geometrical to complete abstraction. As soon as we accede to a *geometrical law* we effect a highly surprising mental inversion, as keen and sweet as an engendering act: curiosity gives place to the hope of creating. The first geometrical representation of phenomena being essentially an *ordering*, this first ordering opens before us perspectives of an abstraction which, alert and conquering, should lead us to organise phenomenology rationally as a theory of *pure order*. Disorder cannot then be called an order that has been misunderstood nor can order be described as the simple concordance of objects and our schemata, as could be the case in the realm of the immediate data of consciousness. When it comes to experiences that reason either advises or constructs, order is a truth and disorder an error. Abstract order is therefore an *order that has been proved* and that does not fall within Bergson's critique of *order that has been found*.[1]

Our intention in this book is to show this grand and imposing destiny of abstract scientific thought. In order to do so, we must prove that *abstract thought* is not synonymous with a *bad scientific conscience*, as the common accusation seems to imply. We shall have to prove that abstraction clears the mind of encumbrances, that it lightens the mind and makes it more dynamic. Proof of this will be found when we look more specifically at the *difficulty* of making correct abstractions, when we note how inadequate are the first attempts at abstraction and how cumbersome the first schemata, when we emphasise too the discursive character of that abstract and essential coherence which cannot reach its goal in a single movement. And in order to make it clear that abstraction does not proceed uniformly, we shall not hesitate to introduce a polemical note at times and argue that experience that is ostensibly concrete and real, natural and immediate presents us with an *obstacle*.

We shall study many branches of the evolution of science so as to give a good description of the path from perception that is reckoned to be accurate to the abstraction that reason's objections so happily inspire. And as scientific solutions are never at the same stage of development where different problems are concerned, we shall not be offering a sequence of general overviews here; we are not afraid of fragmenting our arguments in order to remain in contact with facts that are as precise as possible. However, if for the sake of initial clarity we were obliged to apply crude historical labels to the different ages of scientific thought, we could fairly clearly discern three main periods.

The first period representing *the pre-scientific stage* would include both classical antiquity and those centuries of revival and new efforts that are the sixteenth, seventeenth, and even the eighteenth century.

The second period representing *the scientific stage*, in preparation at the end of the eighteenth century, would cover the whole of the nineteenth century and the beginning of the twentieth century.

Thirdly, the era of *the new scientific mind* could be very precisely dated from 1905, when Einstein's relativity came along and deformed primordial concepts that we thought were fixed forever. From then on, reason multiplied its objections, dissociating fundamental ideas and then making new connections between them, trying out the boldest of abstractions. Over a period of twenty-five years, ideas appear that signal an amazing intellectual maturity, any one of which would suffice to shed lustre on the century. Among these are quantum mechanics, Louis de Broglie's wave mechanics, Heisenberg's physics of matrices, Dirac's mechanics, abstract mechanics, and doubtless there will soon be abstract physics which will order all the possibilities of experience.

We shall not feel compelled though to set our own observations within this triptych for it would not allow us to sketch in accurately enough the detail of the psychological development that we wish to describe. It must again be stressed that the psychic forces at work in scientific knowledge are more confused, more short-winded and more faltering than can be imagined when measuring them from the outside, in the books where they lie waiting for readers. Between the printed book and the book we read there is indeed a great distance, just as there is between one we read and one we understand, assimilate, and remember. Even in a clear mind there are dark areas, caverns still haunted by shades, and traces of the old remain in our new ways of thinking. The eighteenth century still lives secretly within us and may – alas – return. We do not see this as proving the permanence and fixity of human reason, as Meyerson[2] thought, but rather as evidence of the somnolence of knowledge and the miserliness of cultivated minds that go over and over the same knowledge and culture and become, as all misers do, victims of the gold they so lovingly finger. We shall indeed show the improper endosmosis occurring when the assertoric is made to flow into the apodeictic and memory into reason. We shall stress that no one can say they have a scientific mind unless they are certain that at every moment of their thinking life they are reconstructing all their knowledge. Rational axes alone permit these reconstructions: all the rest is base mnemonics. A scholar's patience is utterly different from that of a scientist.

Since all scientific knowledge must be reconstructed at every moment, our epistemological demonstrations will have everything to gain from being worked out with reference to particular problems, without any concern with their historical order. Similarly we will not hesitate to offer plenty of exam-

ples if we wish to show that, on every issue and for all phenomena, we must pass first from image to geometrical form and then from geometrical to abstract form if we are to follow the normal psychological path of scientific thought. We shall nearly always begin therefore with the often very vivid images of primary phenomenology; we shall see how appropriate geometrical forms then replace these images and the difficulties they encounter in doing so. It is hardly surprising that this very difficult, very slow geometrisation should long be regarded as a definitive achievement and that it should suffice to constitute the unshakeable scientific mind as it appears in the nineteenth century. We attach great value to what has been painfully won. It will have to be proved however that this geometrisation is an intermediate stage.

Yet our discussion of particular issues, fragmenting as it does both problems and experiences, will only be clear if it is permissible for us to refer, though without implying any historical correspondence here, to a kind of *law of the three stages* for the scientific mind. In each scientific mind's individual formation, there would therefore be a necessary passage through the following three stages, which are much more precise and particular than were Comte's versions of these.[3]

First, there is *the concrete stage* in which the mind delights in the phenomenon's first images and draws on a philosophical literature glorifying nature and celebrating rather curiously both the world's unity and its rich diversity.

Second, there is *the concrete-abstract stage* in which the mind adds geometrical schemata to physical experience and draws on a philosophy of simplicity. The mind is once again in a paradoxical situation: the more clearly is its abstraction represented by a sensory intuition, the surer it is of this abstraction.

Third, there is *the abstract stage* in which the mind sets to work on information deliberately abstracted from the intuition of real space, deliberately detached from immediate experience and even engaged in an open polemic with primary reality, which is always impure and formless.

So as to complete our description of these three stages of scientific thought, we must then think about the different *interests* that in a way constitute their affective basis. To be precise, the psychoanalysis we are proposing to bring into an objective culture must displace these interests. We would like to suggest here, even at the risk of over-emphasis, that in the affective character of intellectual culture we discern something that makes for confidence and unshakeability and that has not been sufficiently studied. Is it not a teacher's main duty, at whatever level, to give and above all retain a vital

interest in research which is disinterested? But this interest also has a history and even if it means being accused of facile enthusiasm, we must attempt to show it powerfully at work all through scientific *patience*. This patience would be pain without this interest. With it, such patience is a life of mind and spirit. Developing the psychology of scientific patience will involve adding to the law of the three stages of the scientific mind a kind of law of the three stages of the soul, which are characterised by interests.

First, there is *the puerile, childlike soul, the modish, dilettante soul*, filled with naive curiosity and marvelling at any phenomenon instruments produce, playing at physics for amusement and as an excuse for adopting a serious attitude, happily collecting things that come its way and remaining passive even in the joy of thinking.

Next, there is *the teacherly soul*, proud of its dogmatism and fixed in its first abstraction, resting throughout its life on the laurels of its schooldays, its knowledge spoken out loud every year, imposing its proofs on others and wholly devoted to that deduction which so conveniently bolsters authority, teaching its servant as Descartes did or middle-class youngsters as do the proud holders of university degrees.[4]

Lastly, there is *the soul desperate to abstract and reach the quintessential*, a suffering scientific consciousness, given over to ever imperfect inductive interests and playing the dangerous game of thought that has no stable experimental support; it is constantly disturbed by the objections of reason, time and again casting doubt on the right to make a particular abstraction yet very sure that abstraction is a duty, the duty of scientists, at last refining and possessing the world's thought.

Can such conflicting interests be brought together? In any case, the task of the philosophy of science is very clear: it is to psychoanalyse interest, to destroy all utilitarianism, however disguised its form and lofty the status it claims, and to turn the mind from the real to the artificial, from the natural to the human, from representation to abstraction. Now more perhaps than it has ever done, the scientific mind needs to be defended and *illustrated* just as Du Bellay's *Défense et illustration de la langue française*[5] strove both to defend the French language and to illustrate it in the sense of making it illustrious, that is to say conferring honour upon it and celebrating it. This celebration cannot though be just a sublimation of common aspirations in all their diversity. It must be normative and coherent. It must make the pleasure of mental stimulation in the discovery of truth a very conscious and active one. And out of truth it must make our brains. The love of science must be an autogenous psychic dynamism. In the purity that a psychoanalysis of objective knowledge gives it, *science is the aesthetic of the intellect.*

We ought at this point to say something about the tone of this book. Our task being to relate the fight against a number of prejudices, polemics will often take precedence. It is moreover far harder than people think to separate architectonic reason from polemical reason, since the rational critique of experience is indeed one and the same thing as the theoretical organisation of experience: reason's objections are all pretexts for experience, for experiment. It has often been said that a scientific hypothesis that cannot come up against any contradiction is not far from being a useless hypothesis. Similarly, what is the use of an experiment that does not rectify some error and that is just plain true and indisputable? A *scientific* experiment is therefore one that *contradicts ordinary, everyday* experience. Moreover, immediate, everyday experience always has a kind of tautological character, developing in the realm of words and definitions; what it lacks in fact is the perspective of *rectified errors* that in our view characterises scientific thought. Ordinary, everyday experience is not really organised and *composed*; it is, at the very most, made up of juxtaposed observations and we are struck by the fact that the old epistemology established continuity between observation and experimentation whereas experimentation ought instead to distance itself from the ordinary conditions of observation. Since everyday experience is not organised and *composed*, we are of the opinion that it cannot actually be *verified*. It remains a fact. It cannot give us a law. If we are to confirm what is true scientifically, we have to verify it from several points of view. Thinking an experience means therefore giving coherence to an initial pluralism.

Yet however hostile we may be to the pretensions of 'concrete' minds that believe the given can be immediately grasped, our aim here is not the systematic incrimination of every isolated intuition. There will be clear evidence of this when we come to give examples where factual truths are immediately integrated into science. It seems to us though that epistemologists – and this is what distinguishes them from historians – should, when dealing with all the knowledge of a particular period, draw attention to the productive ideas. For epistemologists, ideas must not just have had proven existence, they must also have had an intellectual destiny. We shall not hesitate therefore to ascribe to error – or to intellectual futility, which is pretty much the same thing – any truth which is not part of a general system, any experiment, however accurate, which remains unconnected with a general method of experimentation, and any observation which, however real and positive it may be, is made known in a false perspective of verification. A critical method

of this kind requires an expectant attitude that is almost as prudent with regard to the known as to the unknown, always cautious where familiar knowledge is concerned, and with scant respect for truth that is taught. It is therefore understandable that a philosopher who follows the development of scientific ideas in the work of bad as well as good writers and of naturalists as well as mathematicians, should find it hard to avoid an impression of systematic incredulity. It is understandable too that he may sometimes adopt a sceptical tone out of keeping with what is in other respects his firm faith in the progress of human thought.

NOTES

1 Bachelard's reference is to Bergson's discussion of order and disorder in Chapter 3 of *L'Évolution créatrice* (1907); Henri Bergson, *Creative Evolution*, trans. A. Miller (Lanham: University Press of America, 1983).

2 Émile Meyerson (1859-1933) was an influential philosopher of science whom Bachelard strongly criticised throughout his epistemological work. While Meyerson was unusual among philosophers of the day in that he paid close attention to developments in science, for example to non-Euclidean geometry, relativity theory, and quantum mechanics, he did not believe that science changes the way we think, arguing instead that the mind obeys its own fixed rules, proceeding by deduction and reducing diversity to identity. Thus, Bachelard's *La Valeur inductive de la relativité* (Paris: Vrin, 1929) was written against Meyerson's *La Déduction relativiste* (Paris: Payot, 1925); he frequently expressed his opposition to Meyerson's *Identité et réalité* (Paris: Alcan, 1908; reprinted 1912, 1926, 1932, 1951).

3 Bachelard's reference is to the three stages in the progress of the human mind postulated by Auguste Comte (1798-1857), the founder of French positivism, as the theological, the metaphysical, and the positive. Comte begins his *Cours de philosophie positive* (1830-1842) by stating the 'great fundamental law' according to which 'each of our principal conceptions and every branch of our knowledge' must of necessity start from the first stage, progress to the second, and then to the third, this being the mind's 'fixed and definitive stage'.

4 Bachelard's footnote refers to a section in the French translation of H. G. Wells, *The Open Conspiracy: Blue Prints for a World Revolution* (London: Gollancz, 1928).

5 First published in 1549, Du Bellay's book is one of the great works of the French Renaissance; a manifesto in favour of the French language, it defends it against misuse by bad writers, suggests reforms, and celebrates its virtues, exhorting French writers to use their own language rather than Latin and Greek.

Chapter One

The idea of the epistemological obstacle

I

When we start looking for the psychological conditions in which scientific progress is made, we are soon convinced that *the problem of scientific knowledge must be posed in terms of obstacles*. This is not a matter of considering external obstacles, such as the complexity and transience of phenomena, or indeed of incriminating the weakness of the senses or of the human mind. It is at the very heart of the act of cognition that, by some kind of functional necessity, sluggishness and disturbances arise. It is in the act of cognition that we shall show causes of stagnation and even of regression; there too we shall discern causes of inertia that we shall call epistemological obstacles. Knowledge of reality is a light that always casts a shadow in some nook or cranny. It is never immediate, never complete. Revelations of reality are always recurrent. Reality is never 'what we might believe it to be': it is always what we ought to have thought. Empirical thought is clear *in retrospect*, when the apparatus of reason has been developed. Whenever we look back and see the errors of our past, we discover truth through a real intellectual repentance. Indeed, we know *against* previous knowledge, when we destroy knowledge that was badly made and surmount all those obstacles to spiritualisation that lie in the mind itself.

The idea that we start from scratch when creating and increasing our possessions could only arise in cultural systems based on simple juxtaposition, where something that is known is immediately something that enriches. Yet when our soul confronts all the mystery of reality, it cannot make itself ingenuous just by decree. It is impossible then to erase every single trace of our ordinary, everyday knowledge once and for all. When we contemplate reality, what we think we know very well casts its shadow over what we ought to know. Even when it first approaches scientific knowledge, the mind is never young. It is very old, in fact, as old as its prejudices. When we enter the realms of science, we grow younger in mind and spirit and we submit to a sudden mutation that must contradict the past.

Science is totally opposed to opinion, not just in principle but equally in its need to come to full fruition. If it happens to justify opinion on a particular point, it is for reasons other than those that are the basis of opinion; opinion's right is therefore always to be wrong. Opinion *thinks* badly; it does not *think* but instead *translates* needs into knowledge. By referring to objects in terms of their use, it prevents itself from knowing them. Nothing can be founded on opinion: we must start by destroying it. Opinion is the first obstacle that has to be surmounted. It is not enough for example to rectify opinion on specific points, so maintaining provisional common knowledge like some kind of provisional morality. The scientific mind forbids us to have an opinion on questions we do not understand and cannot formulate clearly. Before all else, we have to be able to pose problems. And in scientific life, whatever people may say, problems do not pose themselves. It is indeed having this *sense of the problem* that marks out the true scientific mind. For a scientific mind, all knowledge is an answer to a question. If there has been no question, there can be no scientific knowledge. Nothing is self-evident. Nothing is given. Everything is constructed.

Knowledge gained through scientific effort can itself decline. An abstract question, freely and openly expressed, will become worn out, with just the concrete answer remaining. The mind's activity is consequently reversed and blocked. An epistemological obstacle will encrust any knowledge that is not questioned. Intellectual habits that were once useful and healthy can, in the long run, hamper research. As Bergson has so rightly said, 'our minds have the irresistible tendency to regard the idea most often of use to them as being the clearest'.[1] Ideas will thus acquire far too much intrinsic clarity. And with use, ideas take on unwarranted *value*. A value in itself impedes the circulation of values. It is a factor of inertia for the mind. On occasion, a dominant idea will polarise the mind in its totality. An irreverent epistemologist said, some twenty years ago, that great men are useful to science in the first half of their lives and harmful in the second. The *formative* instinct is so persistent in some thinkers that this witticism should not alarm us. Yet this *formative* instinct will in the end yield to one that is *conservative*. There comes a time when the mind's preference is for what confirms its knowledge rather than what contradicts it, for answers rather than questions. The conservative instinct then dominates and intellectual growth stops.

As can be seen, we do not hesitate to refer to instincts in order to underline the real resistance put up by some epistemological obstacles. This is

a view that we shall try to justify as our argument develops. At this point though it must be recognised that empirical knowledge – which is the knowledge we are almost exclusively studying in this book – engages sentient human beings via all aspects of their sensibility. When empirical knowledge is rationalised, we can never be sure that primitive sense values are not coefficients attaching themselves to reasons. It can very clearly be seen that an over-familiar scientific idea becomes weighed down by too much psychological concreteness, amassing too many analogies, images, and metaphors, and gradually losing its *vector of abstraction*, its sharp abstract point. In particular, we fall prey to an attitude of vain optimism if we think that *knowing* leads automatically to knowing, that learning becomes easier the more extensive it is, and that intellect, officially recognised by early successes and by prowess in passing competitive examinations, can be capitalised as if it were material wealth. Even allowing that a *well-drilled mind* may escape the intellectual narcissism so common in literary culture and in the passionate espousal of judgements of taste, it can certainly be said that a well-drilled mind is unfortunately a closed mind. It is a product of education.

Critical moments in the growth of thought involve in fact a total reorganisation of the system of knowledge. The well-drilled mind must then be remade. It changes species. It sets itself against the previous species through a decisive function. Through the mental revolutions that scientific invention requires, humankind becomes a mutating species, or to put it better still, a species that needs to mutate, that suffers if it does not change. Mentally, humans need to need. Take for example the psychic modification that comes about when a theory such as relativity or wave mechanics is understood and these phrases will not perhaps seem an exaggeration, especially bearing in mind the real solidity of pre-relativity science. We shall be coming back to these points in our final chapter here, after having given many examples of mental revolutions.

It is also often said that science craves unity, that it tends to identify very diverse phenomena, and that it seeks simplicity or economy in principles and also in methods. Contrary to this however, scientific progress is at its clearest when it gives up philosophical factors of easy unification such as the creator's unity of action, nature's unity of plan, or logical unity. Indeed, these factors of unity, active though they still were the in pre-scientific thought of the eighteenth century, are never invoked these days. Any contemporary scientist wishing to unite cosmology and theology would be regarded as very pretentious.

In the very detail of scientific research, when the scientific mind is dealing with a very specific experience which could indeed be regarded as

truly one and complete, it is never short of ways of varying the conditions here. In a word, it can always find ways of leaving the contemplation of the *same* and seeking the *other*, and of dialectising this experience. In this way, chemistry multiplies and completes its homologous series to the point at which it *leaves nature* and materialises the more or less hypothetical bodies suggested by inventive thought. And in this way in all the rigorous sciences, anxious thought is wary of more or less obvious *identities*, constantly demanding more accuracy and ipso facto more opportunities for making distinctions. Specifying, rectifying, diversifying: these are dynamic ways of thinking that escape from certainty and unity, and for which homogeneous systems present obstacles rather than imparting momentum. To sum up, the scientific mind may make us desire to know, but this from the first is so that we can ask better questions.

II

The idea of the *epistemological obstacle* can be examined in the historical development of scientific thought and also in educational practice. In both these areas, such an examination will prove far from easy. History is in fact intrinsically hostile to all normative judgements. We are obliged however to take a normative view if we wish to evaluate the efficacy of thought. Not everything we find in the history of scientific thought contributes to the development of that thought, far from it. There are some kinds of knowledge which, even though they are accurate, bring useful research to a premature end. Epistemologists must be selective then in their use of the material historians provide. They have to evaluate these documents from the standpoint of reason and indeed from the standpoint of developed reason for it is only now that we can really judge the errors of the mind's past. Moreover, even in the experimental sciences it is always rational interpretation that fixes facts in their correct position. Success and danger both lie along the axis that joins experiment and reason and in the direction of rationalisation. Reason alone can dynamise research for it is reason alone that goes beyond ordinary experience (immediate and specious) and suggests scientific experiment (indirect and fruitful). It is therefore this striving towards rationality and towards construction that must engage the attention of epistemologists. We can see here what distinguishes the epistemologist's calling from that of the historian of science. Historians of science have to take ideas as facts. Epistemologists have to take facts as ideas and place them within a system of thought. A fact that a whole era has misunderstood remains a *fact* in historians' eyes. For epistemologists however, it is an *obstacle*, a counter-thought.

It is when we examine the idea of the epistemological obstacle in greater depth that we shall best discern the true intellectual value of the history of scientific thought. Although the preoccupation with objectivity leads historians of science to catalogue their texts in great detail, all too often it fails to take them further, that is to the measurement of psychological variations in the interpretation of just one text. The same word can at the same period in time have within it very many different concepts. What misleads us here is the fact that the same word both denotes and explains. What is denoted stays the same but the explanation changes. The telephone for instance is understood in very different ways by the subscriber, the operator, the engineer, and the mathematician concerned with the differential equations of the telephone current.[2] Epistemologists must therefore make every effort to understand scientific concepts within real psychological syntheses, that is to say within progressive psychological syntheses, by establishing an array of concepts for every individual idea and by showing how one concept has produced another and is related to another. Then perhaps they may succeed in measuring epistemological efficacy. And straightaway, scientific thought will be seen as a difficulty that has been overcome, an obstacle that has been surmounted.

When it comes to education, the idea of the epistemological obstacle is equally ill-understood. I have often been struck by the fact that science teachers, even more than other teachers if this is at all possible, cannot understand that their pupils may not understand. Very few of them have made a close study of error, of ignorance, and of thoughtlessness. Gérard-Varet's book has met with little response.[3] Science teachers imagine that the mind begins like a lesson. They imagine too that pupils can always make good the slapdash knowledge they have indifferently acquired just by repeating a year, and that pupils can be made to understand a proof if the teacher keeps going over it, point by point. They have not given any thought to the fact that when young people start learning physics they already possess a body of empirical knowledge. It is not therefore a question of *acquiring* experimental culture but rather of *changing* from one experimental culture to another and of removing the abundance of obstacles that everyday life has already set up. Let us take just one example: the buoyancy of floating bodies is the object of a familiar intuition that is shot through with errors. The activity here is more or less openly ascribed to the floating body, or rather to the *swimming* body. If we put our hands on a piece of wood and try to sink it, it will resist. We find it hard to ascribe this resistance to the water. It is not easy therefore to teach the principle of Archimedes so that it is understood in all its marvellous mathematical simplicity unless we have first criticised and undermined this complex and impure body of primary intuitions. In particular, without this psy-

choanalysis of initial errors we shall never be able get children to understand that a body that emerges from a fluid and one that is completely immersed in it are both obeying the same law.

Thus, all scientific culture must begin with an intellectual and emotional catharsis and we shall be explaining this in some detail later on. The hardest of our tasks still remains: we must put scientific culture on the alert so that it is always ready to move, we must replace closed, static knowledge with knowledge that is open and dynamic, and dialectise all experimental variables. Reason must in short be given reasons for developing.

We could moreover generalise these observations: while they are at their most apparent in the teaching of science, they are relevant to all aspects of education. In the course of a career that has already been long and varied, I have never seen a teacher change his or her teaching method. Teachers have no *sense of failure* precisely because they consider themselves to be masters or mistresses. Teaching means commanding. This makes for a great flood of instincts. Von Monakow and Mourgue[4] have in fact noted how difficult it is to reform teaching methods, referring here to the mass of instincts that weighs on every teacher. Thus, they observe that 'There are individuals for whom any advice with respect to the *educational errors* they commit is completely and utterly useless because these so-called errors are simply the expression of instinctive behaviour'. Von Monakow and Mourgue are of course discussing 'psychopathic individuals' yet the psychological relationship between teacher and pupil can easily become a pathogenic one. The teacher and the taught both come under a particular kind of psychoanalysis. We must not in any case neglect the study of the lower forms of the psyche if we wish to describe every aspect of mental and spiritual energy and prepare the cognito-affective control that is indispensable for the progress of the scientific mind. More precisely still, it is by revealing epistemological obstacles that we can help to establish the rudiments of a psychoanalysis of reason.

III

These general remarks will be better understood, however, once we have studied specific epistemological obstacles and well-defined difficulties. We shall now explain therefore the plan we shall be following in this book.

Primary experience or to be more precise, primary observation is always a first obstacle for scientific culture. Indeed, this primary observation brings with it a profusion of images: it is vivid, concrete, natural, and easy. You need only describe it and marvel. And then you think you understand it.

We shall begin this study by describing this obstacle and by showing there to be not continuity but rather a break between observation and experimentation.

Immediately after describing the seductions of particular and colourful observation we shall show how dangerous it is to follow initial generalities, for as d'Alembert has so rightly said we generalise what we first notice when, just a moment before this, we had noticed nothing. We shall thus see the scientific mind hampered at its birth by two obstacles which are in a way opposites. We shall therefore have the chance to see empirical thought oscillating in fits and starts, tugged in different directions and in the end completely dislocated. Yet this dislocation makes useful movements possible. The epistemologist is consequently at the mercy of contrary valorisations which can be fairly concisely summarised by the following objections. It is necessary for thought to leave immediate empiricism. Empirical thought thus acquires a system. Yet the first system is incorrect. Though incorrect, it at least serves the useful purpose of releasing thought by distancing it from sensory knowledge; thus, the first system mobilises thought. The mind that has been constituted in a system can then go back to experience equipped with outlandish ideas, ideas that are at the same time aggressive and questioning, and with a kind of metaphysical irony that is very noticeable in young experimental scientists, so sure of themselves and so quick to observe reality in terms of their theory. Thus, when we go from observation to system, we go from having our eyes wide with wonder to having them tightly shut.

It is very striking moreover that, generally speaking, obstacles to scientific culture always present themselves in pairs, to the point where we could speak of a psychological law of the bipolarity of error. When a difficulty turns out to be a substantial one, you can be sure that as you get round it you will come up against an obstacle which is its very opposite. This kind of regularity in the dialectic of error cannot come naturally from the objective world. In our view, it stems from the polemical attitude of scientific thought where the scientific community is concerned. As in a scientific activity, we have to invent, we have to consider the phenomenon from a new angle. But we have to justify our invention: we therefore think our phenomenon by criticising that of others. And little by little, we are led to make our objections into objects and transform our criticisms into laws. We keep working away at varying the phenomenon in terms of our opposition to other people's knowledge. It is of course in a young science especially that we can see this worthless originality which only serves to reinforce opposite obstacles.

Once we have tackled the problem that concerns us by studying both

the concrete and the systematic mind, we shall go on to deal with obstacles which are rather more particular. Our plan will then have to be a loose one and we shall find it pretty impossible to avoid repeating ourselves since it is the nature of epistemological obstacles to be intermixed and polymorphous. It is also very difficult to establish a hierarchy of error and to describe in an orderly way the disorders of thought. The objects on view in our chamber of horrors will therefore be presented higgledy-piggledy and it will be up to the reader to skip over tedious examples once the points we are arguing have been grasped. We shall be looking in turn at the danger of explaining things by the *unity* of nature and the *usefulness* of natural phenomena. We shall devote a chapter to the description of *verbal obstacles*, that is to say the false explanations obtained with the help of explanatory words through that strange inversion that considers itself to be developing thought by analysing a concept instead of engaging a particular concept in a rational synthesis.

Verbal obstacles will lead on fairly naturally to the study of one of the hardest obstacles to surmount, supported as it is by a facile philosophy. We are referring here to substantialism, to the monotonous explanation of properties by substance. We shall then seek to show that realism is for physicists – and this is not to prejudge its value for philosophers – an unproductive metaphysics in that it halts research rather than provoking it.

We shall end the first part of this book with a study of a very particular obstacle which can be very precisely delimited and which will consequently illustrate as clearly as it is possible to do the idea of the epistemological obstacle. Its full title is *the animist obstacle in the physical sciences*. While it has been almost entirely surmounted by nineteenth-century physics, it is very clear in the seventeenth and eighteenth centuries, so much so that it is in our view one of the characteristics of the pre-scientific mind. We shall therefore make it a more or less absolute rule to describe this obstacle by looking at seventeenth and eighteenth-century physicists. Setting this kind of limit will perhaps underline the point of our argument since the power of an obstacle will be seen at the very time when it is about to be surmounted. This animist obstacle is moreover only distantly related to the animist mentality much studied by all ethnologists. We shall be making this an extensive chapter precisely because this characteristic might be thought no more than an unpromising oddity.

With the ideas of substance and life, each of them ingenuously conceived, innumerable valorisations are introduced into the *physical* sciences to the detriment of the real values of scientific thought. We shall therefore propose special kinds of psychoanalysis in order to rid the scientific mind of these false values.

After studying the obstacles that empirical knowledge must surmount, we shall come in our penultimate chapter to show the difficulties of giving geometrical and mathematical form, together with those of founding a mathematical physics capable of provoking discoveries. Here again, we shall amass examples taken from clumsy systems and unsuccessful geometrisations. It will be seen how *false rigour* is a block to thought and how a first mathematical system can sometimes prevent a new system from being understood. We shall moreover restrict ourselves to making fairly elementary observations, for the sake of readability. To complete our task here, we would in addition need to study the formation of the mathematical mind from the same critical standpoint. This however will be undertaken in another book.[5] This division is possible, we believe, because the growth of the mathematical mind is very different from that of the scientific mind as it strives to understand physical phenomena. Indeed, the history of mathematics is wonderfully regular. There are periods when it comes to a halt. There are though no periods of error. None of the arguments we are putting forward in this book has any bearing on mathematical knowledge. Our arguments here deal only with knowledge of the objective world.

It is this knowledge of objects that we shall, in our last chapter, examine in all its generality, pointing out all that can disturb its purity and diminish its educational value. We believe that we are thus working towards the moralisation of science, deeply convinced as we are that those who follow the laws of the world are already submitting to a great destiny.

NOTES

1 Bachelard's footnote: *La Pensée et le mouvant* (Paris: 1934), 231. The quotation is taken from Bergson's essay 'Introduction to Metaphysics'; Henri Bergson, *Creative Mind*, trans. M. L. Andison (New York: Citadel Press, 1992).

2 Bachelard's choice of the telephone as an example here is a reminder of his early ambition to train as an engineer in telegraphy; see Introduction, note 12.

3 Bachelard's footnote: Louis Gérard-Varet, *L'Ignorance et l'irréflexion: essai de psychologie objective* (Paris: Alcan, 1899).

4 Bachelard's footnote: Constantin von Monakow and René Mourgue, *Introduction biologique à l'étude de la neurologie et de la psychopathologie: intégration et désintégration de la fonction* (Paris: Alcan, 1928), 28.

5 Bachelard did not complete this project, perhaps because the next few years (1938-48) came to be devoted to his work on poetic images; see Introduction, notes 15 and 16.

Chapter Two

The first obstacle: primary experience

I

In the formation of a scientific mind, the first obstacle is primary experience, the experience we place before and above that criticism which is necessarily an integral part of the scientific mind. And because no explicit criticism has been brought to bear on it, primary experience cannot in any circumstances be regarded as utterly reliable. Although we shall be providing many proofs of the fragility of primary knowledge, we are keen to express here and now our strong opposition to a facile kind of philosophy. The philosophy we oppose is one that rests on more or less unequivocal, more or less romanticised sensualism, and that claims its lessons come directly from a clear, distinct, reliable, and constant *given* which is always offered to an always open mind.

Here then is the philosophical argument we shall be advancing: the scientific mind must be formed *against* nature, against all that comes from nature's impetus and instruction, within us and outside us, against natural allurements and colourful, diverse facts. The scientific mind must be formed by being reformed. It can only learn from nature by purifying natural substances and by bringing order to a jumble of phenomena. Psychology itself would become scientific if, like physics, it became discursive and if it realised that both within us and outside us, we understand nature by resisting it. From our point of view, the only legitimate intuition in psychology is the intuition of an inhibition. This though is not the place to develop an essentially reactive psychology. We simply wish to draw attention to the fact that the psychology of the scientific mind we are putting forward here corresponds to a kind of psychology that could be generalised.

Understanding the point of this argument is fairly difficult at first be-

cause nowadays, science teaching in junior classes at secondary-school level has slipped between nature and observer a largely correct, largely corrected book. Physics textbooks, patiently copied from one another as they have been for the last fifty years, offer our children a very socialised and immobilised kind of science which, thanks to the very curious permanence of the syllabus for our competitive examinations, comes to be regarded as *natural*. But it is not at all natural; it is natural no longer. It is no longer *the* science of town and countryside. It is *a* science developed in a bad laboratory yet nonetheless having the distinction of being produced in a laboratory. It may be a case of the local electricity station which, when it supplies the power, also brings us the phenomena of that *antiphysis* – that antinature – which Berthelot saw as the sign of a new era; experiences and books are therefore now to some extent detached from our primary observations.

This was not the case in the pre-scientific period, in the eighteenth century. Science books could then be either good or bad. They were not subject to the scrutiny and *control* of education officials. When they bore some sign of scrutiny, this was often by learned societies in provincial towns whose members were drawn from the most muddle-headed and best connected of circles. So science books *started* from nature. They took an interest in everyday life. They popularised popular knowledge without having the hidden intellectual agenda that sometimes makes our popularising works too highbrow. Writers and readers thought at the same level. Scientific culture was weighed down as it were by the mass and variety of minor works, which greatly outnumbered those of real value. It is very striking that the opposite is the case in our day when books that popularise scientific knowledge are relatively rare.

Open a modern science textbook and you will see that it presents science in relation to an over-all theory. Its organic structure is so obvious that it would be very hard to skip chapters. Scarcely have the first few pages been perused when the voice of common sense is silenced; readers' questions now go entirely unheeded. The old prefatory phrase 'Dear Reader' could easily be replaced by a severe 'Pay attention, children'. The book asks its own questions. The book commands.

Open an eighteenth-century science book and you will realise that it is rooted in everyday life. The author converses with readers like one giving a talk in polite society. The interests and concerns he espouses are *natural*. Take for example the question of the cause of thunder. The fear of thunder will be talked about and there will be an attempt to show readers that this fear is groundless, with the author feeling the need to repeat the oft-made observation that when there is thunder, the danger is over for lightning alone can

kill. Thus, in the Abbé Poncelet's book entitled *La Nature dans la formation du Tonnerre et la reproduction des Etres vivants* (1769), the first page of the preface states that 'In writing about Thunder, my chief intention has always been to moderate, where possible, the disagreeable impressions that this phenomenon of the atmosphere usually has on an infinity of Persons of all ages, whatever their sex and condition. How many Persons have I not seen who passed their days in violent agitation and their nights in mortal disquiet?' The Abbé Poncelet devotes a whole chapter to reflections on the fright that thunder causes, and this turns out to be the longest chapter in the book, covering some twenty-three pages. He distinguishes four kinds of fear which he analyses in detail. All readers, whoever they may be, therefore have a chance of finding in this book the elements of their own diagnosis. This diagnosis was useful since the hostility of nature then seemed somehow more direct. Nowadays, the main causes of our anxiety are human ones. The greatest suffering of human beings today is inflicted by other humans. Natural phenomena have been rendered harmless by being explained. We shall understand how different are minds separated by a century and a half of time if we ask ourselves whether the following passage, taken from Goethe's *Werther*, still corresponds to a psychological reality:

> Before the dancing ended, the flashes of lightning which for some time we had seen on the horizon but which I had until then passed off as summer lightning intensified considerably, and the sound of thunder drowned the music. Three ladies suddenly left the dance, followed by their partners; there was general disorder and the music stopped ... It is to these causes that I attribute the strange expressions adopted by some of the ladies. The most sensible lady there went and sat in a corner, her back to the window and her fingers in her ears. Kneeling in front of her and burying her head in her lap was another lady. A third had crept between her two sisters, embracing them and weeping copiously. Some ladies wanted to go home. Others grew increasingly distraught and did not even have sufficient presence of mind to defend themselves against the temerity of some audacious young men who seemed bent on plucking from the lips of these fair ladies in distress the prayers that they in their fright were sending up to heaven.[1]

It would seem impossible, I think, to include a narrative of this kind in a modern novel. Such an accumulation of silliness would seem unrealistic. Nowadays, the fear of thunder has been overcome. It is experienced, if at all, only in solitude. It cannot affect us in a social group since we have as a group

entirely *rationalised* the theory of thunder; individual fits of irrationality are now but oddities that are concealed. We would laugh at Goethe's hostess closing shutters and curtains in order to protect a dance.

The pre-scientific book sometimes acquires a particular tone by virtue of its readers' social status. Astronomy for those moving in the best circles must bring in the jests of the great and the good. Claude Comiers, a scholar and a man of great patience, begins his book on comets – a book much quoted in its day – with these words: 'Since there was at Court a heated debate as to whether "Comet" was masculine or feminine in French, one of the field-marshals, wishing to end this Scholars' dispute, announced that in order to see whether it should be *la* or *le* we needed to lift up its tail'.[2] Modern scientists would no doubt not refer to the opinion of a field-marshal. They would not go on endlessly repeating jests about comets' tails and beards: to quote Comiers, 'Just as the tail is held to be always the hardest part of an animal to skin, so the Comet's tail has always been as hard to explain as the Gordian knot to undo'.

In the seventeenth century, dedications in science books are more fulsome in their flattery than those found in literary works, if that is possible. They are in any case all the more shocking for the modern scientific mind, indifferent as it is to political authority. Here is one example of these unimaginable dedications. The writer La Chambre is dedicating his book on digestion to Richelieu: 'Be that as it may, my Lord, it is certain that I owe to you my Knowledge of this subject' (of the stomach, that is). He goes on to prove it thus: 'Had I not seen what you have made of France, I would never have imagined that there was in our bodies a spirit which could soften all hard things, sweeten the bitter, and unite the dissimilar, and which could then make strength and vigour flow into all parts, giving so justly to each all that was needed'. The stomach is thus a kind of Richelieu, the prime minister of the human body.

There is often an exchange of views between author and reader, between the *curious* and the *learned*. For example, a whole series of letters was published in 1787 under the following title: 'Experiments on the properties of lizards, in both their fleshly and their liqueous forms, in the treatment of venereal and herpetic diseases'. A traveller living in retirement at Pontarlier had seen many black people in Louisiana cure themselves of venereal disease 'by eating anolis' (a kind of iguana). He highly recommends this treatment. A course of three lizards a day produces wonderful results which are brought to Vicq d'Azyr's attention.[3] And in a number of letters, Vicq d'Azyr thanks his correspondent.

The mass of erudition that an eighteenth-century science book had to

carry along with it is an obstacle to the book's organic structure. A single example will suffice to show this well-known feature. When dealing with fire in their celebrated *Physique du Monde*, published in Paris in 1780, Baron de Marivetz and Goussier regarded it as both their duty and a matter of pride to examine forty-six different theories before proposing the correct one, which was their own. The reduction of erudition can rightly be taken as the mark of a good modern science book. It can provide a measure of the psychological difference between scientific eras. Seventeenth and eighteenth-century writers quote Pliny far more frequently than we ourselves quote them. The distance from Pliny to Bacon is less than from Bacon to modern scientists. The scientific mind progresses geometrically, not arithmetically.

In its day-to-day teaching, modern science keeps away from any reference to erudition. Indeed, it only grudgingly makes room for the history of scientific ideas. Social organisms like university libraries accept somewhat uncritically literary and historical works of little value but reject those scientific books that are either hermetic or just plain practical. I have looked in vain for cookery books in the university library at Dijon. On the other hand however, the skills of distiller, perfumer, and cook gave rise in the eighteenth century to many works which our public libraries carefully conserve.

The contemporary scientific community is so homogeneous and so closely guarded that the works of mad or disturbed authors are hard to publish. This was not the case a hundred and fifty years ago. I have before me a book entitled *Le Microscope moderne pour débrouiller la nature par le filtre d'un nouvel alambic chymique, où l'on voit un nouveau méchanisme physique universel*. The author is Charles Rabiqueau, advocate-at-court and the King's engineer-optician. The book was published in Paris in 1781. We see here the universe surrounded by infernal flames that produce distillations. The sun is at the centre and measures only five leagues in diameter. We read that 'The Moon is not a body but simply the reflection of solar fire in the aerial vault'. The King's optician has thus generalised the lesson learned from a concave mirror. We are told that 'The stars are but the shrill shattering of our lines of sight on different aerial bubbles'. The symptomatic stressing of the *power* of the gaze can be recognised here. It typifies a predominant *subjective* experience that must be rectified in order to reach the concept of the objective star, the star that is indifferent to the gaze resting upon it. I have several times observed sick people in the asylum staring defiantly at the sun as Rabiqueau does. It would be hard to find a publisher for their wild ideas. They would not find an Abbé de la Chapelle who, having by order of the Chancellor read such a lucubration, would judge it in these terms as he gave it the official stamp: it had always been thought, he says, 'that objects some-

how came and found our eyes; Rabiqueau reverses this perspective and it is the faculty of seeing that goes and finds objects ... Rabiqueau's work announces a corrected Metaphysics, preconceptions overcome, and moral behaviour made more pure, all of which crown his work'.

These general remarks on books that teach the first lessons will perhaps suffice to show the difference in the first contact with scientific thought at the two periods we wish to characterise. Were we to be accused of using many bad writers and forgetting the good ones, our answer would be that good writers are not necessarily those who enjoy success. And since we must study how the scientific mind was born in a free and almost anarchical form – not one sent to school at any rate – as was the case in the eighteenth century, we are indeed obliged to consider all that false science which crushes the true, all that false science *against* which the true scientific mind must in fact be constituted. To sum up, pre-scientific thought lives in the world. It is not *regular*, that is to say it does not live under orders,[4] like the scientific thought trained in official laboratories and codified in schoolbooks. We shall go on to see that working from a slightly different point of view, we have to come to the very same conclusion.

II

In a lively book, Mornet has clearly shown the modish, dilettante character of eighteenth-century science.[5] In coming back to this, we simply wish to add a few points relative to the *interest*, a childlike interest in a way, then aroused by the experimental sciences and also to offer a particular interpretation of that interest. Our argument here is as follows: by giving immediate satisfaction to curiosity and by multiplying the opportunities for curiosity, far from encouraging scientific culture we hinder it. We replace knowledge by wonderment and ideas by images.

In trying to relive the psychology of the amused observer, we shall see the coming of an era of facility which will remove the *sense of the problem* from scientific thought, and with it the motive power of progress. Many examples will be taken here from electrical science and we shall see how late and how exceptional the attempts at geometrisation were in the theories of static electricity, for only with Coulomb's *boring* science were the first scientific laws of electricity found. In other words, modern readers will, in our view, realise as they peruse the many books devoted to electrical science in the eighteenth century how difficult it was to forsake the vividness of primary observation, to take the colour out of electrical phenomena, and to rid experience of its parasitical features and its irregular aspects. It will then be

clear that when the empirical first comes to dominate, it does not even give the correct *delineation* of phenomena nor even a well-ordered, truly hierarchical description of phenomena.

Once the mystery of electricity had been accepted – and a mystery as such is always accepted with alacrity – electricity gave rise to an easy 'science', a science that was very close to natural history and far from the calculations and theorems which had been gradually coming into mechanics, optics, and astronomy after Huyghens and Newton. Priestley is still writing that 'Electrical experiments are, of all others, the clearest, and the most elegant, that the compass of philosophy exhibits'.[6] These first theories, theories dealing with such complex phenomena, thus presented themselves as simple ones, this being the indispensable condition for them to be amusing and interesting to a public moving in the best social circles. Putting it another way and speaking now as a philosopher, these theories presented themselves bearing the mark of an *obvious and deep-seated empiricism*. Intellectual sloth finds it so pleasant to be confined to empiricism, to call a fact a fact and to forbid the search for laws! It is still true today that all those pupils who are bad at physics 'understand' empirical formulas. They readily believe that all formulas, even those stemming from a highly organised theory, are empirical. They imagine that a formula is just a set of numbers sitting there and which you just have to apply to every particular case. Moreover, the empiricism of the first electricity is so very beguiling. It is not simply an obvious but also a *colourful empiricism*. It is not a matter of having to understand it: you only need to see it. Where electrical phenomena are concerned, the book of the world is a picture book. You have to turn its pages without trying to anticipate the surprises in store. Here we can be sure that we could never have foreseen what we are seeing. Priestley rightly says that:

> The electric shock itself, if it be considered attentively, will appear almost as surprising as any discovery that he [Isaac Newton] made; and the man who could have made that discovery, by any reasoning a priori, would have been reckoned a most extraordinary genius: but electrical discoveries have been made so much by accident, that it is more the powers of nature than of human genius, that excite our wonder with respect to them.

Priestley doubtless has a fixed idea about all scientific discoveries being due to chance. Even where his own discoveries are concerned, discoveries he has patiently pursued with remarkable scientific knowledge of chemical experimentation, Priestley does the fashionable thing and erases the theoretical connections that had led him to set up productive experiments. So

great is his aspiration to empirical philosophy that thought is nothing other than a kind of occasional cause of experiment. According to Priestley, everything is the work of chance. For him, luck prevails over reason. Let us therefore wholly concentrate on the spectacle played out before us. Let us pay no attention to the physicist who simply organises the spectacle. This is no longer the case nowadays when what arouses our sense of wonderment is the experimenter's ingenuity and the theoretician's strokes of genius. And in order to make clear the human origin of the phenomenon that has been produced, the experimenters' names are attached – doubtless for all time – to the *effect* they constructed. Examples of this are the Zeeman effect, the Stark effect, the Raman effect, the Compton effect, and also the Cabannes-Daure effect which could serve as an example of what is in a way a *social effect*, having been produced by the collaboration of minds.

Pre-scientific thought does not pursue the study of carefully delimited phenomena. *It does not seek variation but rather variety*. This is a particularly characteristic feature: the search for variety takes the mind from one object to another, unmethodically; the mind only aims therefore at the extension of concepts. The search for variation is attached to a particular phenomenon; it tries to objectify all its variables and test their sensitivity; it enriches the comprehension of a concept and prepares the mathematisation of experience. Let us look though at the pre-scientific mind as it goes in search of variety. We have only to skim through the first books on electricity to be struck by the heterogeneous nature of the objects in which electrical properties are sought. Not that electricity is made a general property: paradoxically, it is held to be an exceptional property which is at one and the same time attached to the most diverse substances. In first place come – naturally – precious stones, followed by sulphur, the residues of calcination and distillation, belemnites, smoke, and flame. Attempts are made to link the electrical property and the properties that are first seen. Having made a *list* of the substances which might be electrifiable, Boulanger concludes from it that 'the most brittle, and the most transparent substances, are always the most electric'.[7] Great attention is always paid to what is *natural*. Since electricity was a *natural* principle, it was for a short while hoped that it offered a way of distinguishing between real and false diamonds. The pre-scientific mind always wishes the natural product to be richer than the artificial one.

To this scientific construction built of juxtaposition alone, everyone has something they can contribute. History is witness to the craze for electricity. Everyone is interested in it, even the king. Priestley recounts a *gala experiment*:

> In France, as well as in Germany experiments were made to try how many persons might feel the shock of the same phial [the Leyden jar]. The Abbé Nollett, whose name is famous in electricity, gave it to one hundred and eighty of the guards, in the King's presence; and at the grand convent of the Carthusians in Paris, the whole community formed a line of nine hundred toises [nine furlongs], by means of iron wires between every two persons (which far exceeded the line of one hundred and eighty of the guards) and the whole company upon the discharge of the phial, gave a sudden spring, at the same instant of time, and all felt the shock equally.

The experiment is named after those watching it, and we are told that if several people standing in a circle receive an electric shock, the experiment is called 'the Conjured'. When it came to volatilising diamonds, people of rank found it astonishing and even dramatic. Macquer did the experiment in front of seventeen people. When Darcet and Rouelle repeated it, a hundred and fifty people were present.[8]

The Leyden jar was the occasion of real amazement, as the following quotations from Priestley show. He tells us that 'in the same year in which it was discovered, numbers of persons, in almost every country in Europe, got a livelihood by going about and showing it. While the vulgar of every age, sex, and rank were viewing this prodigy of nature and philosophy with wonder and amazement'. We also learn that 'An emperor need not desire a greater revenue than the sums which have been received in shillings, sixpences, threepences, and twopences for exhibiting the Leyden experiment'. This use of a few discoveries by itinerant showmen will no doubt be seen in the course of scientific development. It is now negligible however. The *demonstrators* of X-rays who thirty years ago came to see headteachers offering to add a little novelty to lessons would certainly not have amassed a great fortune. They seem nowadays to have disappeared altogether. There is now in the physical sciences at least a great gulf between charlatan and scientist.

In the eighteenth century, science interested all educated people. It was instinctively felt that a natural history collection and a laboratory could be put together like a library, as the occasion arose; it was confidently expected that the hazards of individual finds would be co-ordinated all by themselves, nature herself being both coherent and homogeneous. An anonymous writer, probably the Abbé de Mangin, presents his *Histoire générale et particulière de l'électricité* (1752) with this very symptomatic subtitle: 'or the curious and amusing, useful and interesting, merry and jocular things that have been said about it by some physicists in Europe'. He stresses that his work is very much of interest to those moving in polite society since if they study his

theories, they will be able:

> to say something clear and precise in the different arguments that arise every day in society and on the subject of which the Ladies are indeed the first to put questions ... A young man who might formerly have made a name for himself in these circles simply by virtue of a thin voice and an elegant figure is now obliged to know to some degree at least his Réaumur, his Newton, and his Descartes.

In his *Tableau annuel des progrès de la Physique, de l'Histoire naturelle et des Arts* for the year 1772, Dubois says on the subject of electricity that:

> Every Physicist repeated experiments, everyone wanted to astonish themselves ... A certain Marquis has, we know, a truly delightful Physics laboratory. Electricity is his passion however and if paganism still held sway, he would doubtless erect electric altars. He knew my tastes and was not unaware that I too was beset by *Electromania*. He therefore invited me to a supper at which there would be, he said, the bigwigs, male and female, of the electrifying world.

One would like to get to know this *spoken electricity* which would doubtless reveal more about the psychology of the period than about its science.

We have more detailed information about Franklin's *electric dinner*. Priestley tells the story as follows. In 1748, at a gathering of Franklin and his friends 'A turkey was killed for their dinner by the electric shock, and roasted by the electrical jack, before a fire kindled by the electrified bottle, when the healths of all the famous electricians in England, Holland, France, and Germany, were drunk in electrified bumpers, under a discharge of guns from the electrified battery'. In his *Histoire générale et particulière de l'électricité*, the Abbé de Mangin tells the story of this famous dinner, as so many have done. He adds; 'I think that were Mr Franklin ever to travel to Paris, he would not hesitate to crown his magnificent meal with a good cup of coffee, one that was strongly and properly electrified'. In 1936, a minister inaugurated an *electrified* village. He too ate an *electric dinner* and was none the worse for it. The newspapers devoted much space to this, thus proving that childlike interests are to be found in every era.

We sense moreover that this science which is spread all through a cultivated social group does not really constitute a *scientific community*. The laboratory of the Marquise du Châtelet at Cirey-sur-Blaise, much praised in

so many letters, has absolutely nothing in common with and in no way resembles the modern laboratory in which a whole team works on a precise programme of research, as in for example the laboratories of Liebig or Ostwald, Kammerling Onnes's low-temperature laboratory, or Madame Curie's radioactivity laboratory. The theatre at Cirey-sur-Blaise is a theatre: the laboratory at Cirey-sur-Blaise is not a laboratory. Nothing gives it coherence, neither the person in charge nor the experiment. It has no cohesion other than comfortable surroundings and the fine dining room next to it. It is an excuse for evening or drawing room conversations.

More generally, eighteenth-century science is not a way of life or even a job. At the end of the century, Condorcet still saw the occupations of the lawyer and those of the mathematician as opposite in this respect. The first earn a living and thus have a value that the second lack. On the other hand, where mathematics is concerned, the educational route is well marked out, allowing us at least both to distinguish between pupil and teacher and to give pupils the impression of all the thankless, long hours of work they have to do. Reading Madame du Châtelet's letters is enough to make us smile a thousand times at her pretensions to a mathematical culture. Using all her charms, she puts problems to Maupertuis that nowadays a thirteen or fourteen-year-old child could solve without difficulty. This mincing, simpering mathematics is the very opposite of a healthy scientific education.

III

A social circle of this kind remains frivolous at the very same time that it considers itself wholly devoted to serious occupations. The group has to be held together by offering demonstrations and illustrations of the phenomenon. *Far from going straight to essentials, there is an augmentation of all that is vivid and picturesque*: wires are planted in a ball of pith obtained from an elder tree in order to produce an *electrical spider*. It is however through the reverse epistemological movement, going back to the abstract and tearing off the electrical spider's legs, that Coulomb will find the fundamental laws of electrostatics.

The best minds are amused by the imagery of this new-born science. Volta writes hundreds of pages describing in his letters the wonders of his *electric pistol*. The complex name he gives it is of itself clear evidence of the need to overload the essential phenomenon. He often calls it 'the electrico-phlogo-pneumatic pistol'. In letters to the marquis François Castelli, he stresses the newness of his experiment in these terms:

> If it is curious to see a glass pistol being loaded by pouring millet seed back and forth into it and to see it fired without either tinder, battery, or powder but just by raising a small plate, then it is even more curious – and here astonishment is added to amusement – to see a single electric spark making an interconnected group of pistols all fire at the same time.[9]

Astonishment is systematically sought in order to catch people's interest. Empirical contradictions are amassed. Typical of a fine experiment, eighteenth-century style, is that conducted by Gordon. Priestley tells us that 'Mr Gordon even fired spirits by a jet of water'. In the same way Dr Watson, in Priestley's words, 'even fired both spirit of wine, and inflammable air, by a drop of cold water, thickened with a mucilage made with the seed of fleawort, and even with ice'.

Through empirical contradictions such as these, where fire is lit by cold water or by ice, it is believed that the mysterious character of nature can be discerned. There is not a single book in the eighteenth century that does not feel itself obliged to make reason tremble before the mysterious abyss of the unknowable, and that does not play with the vertigo which seizes us in face of the depths of the unknown. What fascinates us is what first attracts our attention. According to the Abbé de Mangin, 'Together with the natural and the useful in history, electricity seems to unite in itself all the delights of fable and story, of theatrical spectacle and of romance, of comedy and tragedy'. In order to explain the origin of the prodigious interest immediately encountered by electricity, Priestley writes:

> Here we see the course of nature, to all appearances, entirely reversed, in its most fundamental laws, and by causes seemingly the slightest imaginable. And not only are the greatest effects produced by causes which seem to be inconsiderable, but by those with which they seem to have no connection. Here, contrary to the principles of gravitation, we see bodies attracted, repelled, and held suspended by others, which are seen to have acquired that power by nothing but a very slight friction; while another body, with the very same friction, reverses all its effects. Here we see a piece of cold metal, or even water, or ice, emitting strong sparks of fire, so as to kindle many inflammable substances.

This last observation provides good proof of the inertia of the substantialist intuition we shall be examining later on. It shows fairly clearly that this intuition is an obstacle to the understanding of a new phenomenon: indeed, how astonishing it is to see ice that does not 'contain' fire in its sub-

stance throwing out sparks even so! Let us therefore remember this example in which there is an excess of the *concrete* that masks the correct form, the abstract form, of the phenomenon.

Once reverie has taken off into the realms of contradictory images, marvels are condensed with great ease. It leads the most unexpected possibilities to converge. When incombustible asbestos was used to make long-lasting wicks for lamps, it was hoped to find 'eternal lamps'. All that needed to be done, people thought, was to isolate *asbestos oil* which undoubtedly would not burn away any more than an *asbestos wick* does. Many examples could be found of convergences that are as swift and as flimsy as this and that are the source of certain projects thought up by adolescents. In works anticipating the scientific future – works of science fiction – so popular in literary circles where they were regarded as in fact disseminating scientific knowledge among the general public, the same devices were used, with more or less disparate possibilities being juxtaposed. All these worlds which a simple change of scale enlarges or reduces are, as Régis Messac has said in his fine study of Voltaire's *Micromégas*, linked to 'commonplaces which however also correspond to such natural inclinations of the human mind that it is permissible to trot them out to one's heart's content; they can always be successfully repeated to a like-minded public as long as this is done skilfully or with some apparent novelty in the presentation'.[10] For the scientific mind, these science fictions, these journeys to the moon and fabrications of giants and monsters, are real infantile regressions. And while they sometimes amuse, they never instruct.

Explanations are at times entirely based on an excess of parasitic features. This is how real aberrations come about. A vivid image leads to the adoption of an unverified hypothesis. For example, a mixture of iron filings and flowers of sulphur is covered with earth and then has grass planted on top of it: it is then blindingly obvious that what we have is a volcano! It seems that without this garnishment, without this vegetation, imagination would be disconcerted. With them, it can go forward: it need only expand the dimensions and it will 'understand' Vesuvius as it throws up lava and smoke. A healthy mind ought to admit that it has only been shown an exothermic reaction, the synthesis quite simply of iron sulphide. This and only this. This is a chemical problem and the physics of the earth does not come in to it.

Here is another example of vivid detail leading to improper explanation. In a note in Cavallo's treatise on electricity, in which he relates experiments that are often ingenious, he says that he has studied 'the effect of an electric charge passing over a piece of card or another body' and goes on to say that 'if you cover the square of paper with small three-dimensional mod-

els – little houses or other buildings – the shaking caused by the electric charge will fairly naturally represent an earthquake'.[11] The same imagery, but this time used as *proof* of the effectiveness of earthquake and volcano-conductors, can be found in the *Encyclopédie*, in the article entitled 'Earthquakes'.[12] 'I have imagined', writes the Abbé Bertholon, 'and I have had constructed a small machine that represents a town hit by an earthquake and which is saved as soon as the earthquake-conductor or preserver is put in place'. We see then how according for both Cavallo and the Abbé Bertholon the phenomenon of what is simply a physical vibration produced by an electric discharge leads to adventurous explanations when it is over-illustrated.

Images as simplistic as these lead to strange syntheses. Carra is the originator of a general explanation linking the emergence of plants and animals to centrifugal force which, in his view, is related to electric power. It was in this way that quadrupeds that were originally confined to a chrysalis 'were lifted on to their feet by the same centrifugal force that had long been acting upon them and began to walk on dry land'.[13] Carra does not look far for proof of this theory:

> The experiment with a small human figure cut from card, held up and balanced in the ambient air by the vibrations of the electrical machine, offers a fairly clear explanation of how animals with feet or paws were raised up on to their legs and of why some of them continue to walk or run and others to fly. Thus, the electric power in the atmosphere, power that the earth's rotation on itself continues, is the true cause of the faculty animals have of standing on their feet.

It can fairly easily be imagined that an eight-year-old child – possessed of course of a pedantic vocabulary – could come out with such arrant nonsense. It is more surprising in a writer of whom learned societies occasionally took notice and who is quoted by the very best of authors.[14]

In reality, we have difficulty in imagining the importance the eighteenth century ascribed to automata. Cardboard figures 'dancing' in an electric field seemed close to life because their movement lacked an obvious mechanical cause. Voltaire goes as far as to say that Vaucanson's flute-player is closer to humans than a polyp is to animals. For Voltaire himself, external representation with all its images and vividness prevails over inner, hidden resemblances.

De Marivetz, an important writer whose work was very influential in the eighteenth century, develops grandiose theories based on images as flimsy as these. He proposes a cosmogony founded on the sun's rotation on itself. It

is this rotation that determines planetary motion. De Marivetz considers that planets move in spirals 'which are less curved the farther planets are from the Sun'. At the end of the eighteenth century then he does not hesitate to go against Newtonian science. Here again, proofs which are deemed to be sufficient are found without having to look very far for them. Thus we read that:

> The suns made by pyrotechnists provide a perceptible image of the precessions and spirals to which we are referring. In order to produce these effects, the rockets placed along the circumference of these suns must not point towards their centre. If that were the case, the sun could not turn on its axis and the bursts from each rocket would be rectilinear. When though the rockets are placed obliquely to the circumference, the movement of rotation is added to that of the exploding rockets and the rocket burst becomes a spiral that grows less curved the higher it rises up above the centre.

What a curious toing and froing of images this is! The sun of the pyrotechnists was named after the solar planet and in a strange recurrence, we see it offering here an image in illustration of a theory of the sun! Such comings and goings of images are frequent when the imagination is not psychoanalysed. A science that accepts images is, more than any other, a victim of metaphors. Consequently, the scientific mind must never cease to fight against images, against analogies, and against metaphors.

IV

In junior classes in our secondary schools, images and anything vivid and picturesque wreak the same havoc. When there is an experiment using odd apparatus and especially when that experiment has an unexpected name and comes from the very early days of science – like for instance the chemical harmonica – the children in the class will pay close attention to events: what they do not do though is look at the essential phenomena. They hear the roaring of the flame but do not see its striations. And should there be some accident – that triumph of the singular – then interest is at its height. For example, in order to illustrate the theory of radicals in inorganic chemistry, the teacher makes ammonium iodide by passing ammonia several times through a filter covered with grains of iodine. The carefully dried filter paper then explodes if it is ever so slightly creased and the young pupils look on wide-eyed. A chemistry teacher with an insight into psychology will then understand that pupils' interest in *explosions* is impure, especially when ex-

plosive material is so easily obtained. It seems that for adolescents, any explosion suggests the vague intention of harming, of frightening, and of destroying. I have questioned many people about their memories of school. In about fifty per cent of cases, I found the memory of explosions in chemistry lessons. Most of the time, the objective causes of these had been forgotten and what was remembered was the look on the teacher's face and the fright of the shy child nearby: there was never any mention of the narrator's fright. All these memories suggested, by the very alacrity with which they were recalled, the repressed will to power, anarchic and satanic tendencies, and the need to have control over things in order to be able to oppress people. As for the formula of ammonium iodide and the very important theory of radicals illustrated by this explosive, it goes without saying that they are not part of the cultivated person's baggage, not even by virtue of the very special interest aroused by this explosion.

Moreover, it is not uncommon to see young people becoming attached to dangerous experiments. When talking to their families, a large number of pupils exaggerate the dangers they have faced in the laboratory. Many are the fingers turned yellow by some calculated clumsiness. Laboratory coats have holes made in them by sulphuric acid with astonishing frequency. The victim of science's story has indeed to be lived out inside our heads.

In chemistry, many vocations originate in an accident. The young Liebig was apprenticed to a pharmacist at the age of fifteen and soon dismissed: instead of pills, he was making fulminate of mercury. Fulminates were moreover the subject of his first scientific work. Are we to see a purely objective interest in his choice of subject? Is patience in research adequately explained in terms of a fortuitous psychological cause? In Strindberg's *The Son of a Servant*, which is in many respects autobiographical, we find this memory from adolescent days: 'In order to have his revenge in the house where he was a figure of fun because of his unfortunate experiment, he prepared fulminant gases'.[15] Moreover, Strindberg was for many years obsessed by chemical problems. In an interview with a present-day professor, Pierre Devaux writes that 'Like all budding chemists, he had a passion for explosives, for chlorated powders, and for bomb fuses made out of shoe laces'. Such impulses sometimes make for distinguished careers, as indeed the foregoing examples show. More often though a violent experiment is sufficient unto itself and leaves memories that are given unwarranted value.

Summing up then, in the junior years of our secondary schools experiments which are too vivid and which offer too many images are centres of false interest. Teachers cannot be too strongly advised to keep moving from the laboratory bench to the blackboard in order to extract the abstract from

the concrete as soon as possible. They will return to the experiment better equipped to bring out the phenomenon's organic character. Experiments are done in order to illustrate theorems. Reforms introduced into secondary education in France over the last decade have diminished the difficulty of physics problems and even in some cases brought in the teaching of a physics where there are no problems but just oral questions: such reforms misunderstand the real meaning of the scientific mind. Total ignorance is preferable to knowledge that has lost its fundamental principle.

V

When a problem is posed, experience has to be put into a rational form and unless this happens and there is constant recourse to an explicit rational construction, we will allow a kind of *unconscious of the scientific mind* to be constituted, which will then require slow and difficult psychoanalysis if it is to be exorcised. In Édouard Le Roy's strikingly dense phrase 'Everyday knowledge is unconsciousness of oneself'.[16] This unconsciousness can however also affect scientific thought. In that case, criticism must be reinstated and knowledge brought back into contact with the conditions that gave it birth; we must keep returning to that 'nascent state' which is the state of psychic vigour, at the very moment when the answer has come from the problem. It is not sufficient to find *a reason* for *a fact* in order to be able to speak in any real sense of the term of the *rationalisation* of experience. Reason is a psychological activity that is essentially polytropic: it wants to turn problems over, to vary them, to graft them on to one another, and to make them proliferate. For an experience to be truly rationalised it must therefore be inserted into a *set of multiple and interacting reasons.*

This theory of *discursive and complex rationalisation* encounters opposition from our first convictions, from the need for immediate certainty, from the need to *start from* certainty and from the reassuring belief that, because of this, the knowledge we started from was certain. How very ill-tempered we therefore are when someone comes along and contradicts our elementary knowledge, fingering this *childhood treasure*, the fruit of so much effort in the schoolroom! And how quick we are to make accusations of disrespect and self-conceit against anyone who casts doubt on our elders' powers of observation! This being so, such misplaced affectivity ought surely to attract the attention of psychoanalysts. In our view then, Ernest Jones is indeed inspired in his psychoanalytical study of indurate first convictions. We must study these premature 'rationalisations' which play a part in the formation of the pre-scientific mind similar to that of sublimations of the libido in

the artist's formation. They are the mark of a *will* to be in the right without having any explicit proof, and to avoid discussion by referring to a fact that we do not consider ourselves to be interpreting, even though we are giving it an essential *declarative value*. As Louis Castel has so well put it:

> The method that follows facts, authoritarian and despotic as it is, assumes a god-like air, tyrannising our credence and deluding our reason. A man who reasons, or indeed who demonstrates a proof, regards me as a man: I reason with him; he leaves me free to judge; he presses me only by my own reason. He who cries 'here is a fact' regards me as a slave.[17]

The psychoanalysis of objective knowledge is particularly difficult when first 'facts' are adhered to. No new experience and no criticism can, it seems, destroy certain of our first affirmations. At the very most, we concede that primary experiences can be rectified and made more precise by new ones. As though primary observation could yield anything other than an *opportunity* for research! Ernest Jones gives a very pertinent example of this over-hasty, ill-made rationalisation that constructs on an experimental basis lacking in any solidity:

> The current use of valerian as a specific remedy for hysteria provides us with an example of how the process of rationalisation is set in motion. It should be remembered that asafoetida and valerian were administered for centuries because people believed that hysteria was the result of the womb's migrations throughout the body, and these malodorous remedies were held to have the power to restore this organ to its normal position, which should then lead to the disappearance of hysterical symptoms. Even though experience has not confirmed this view, most hysterical diseases are at present still treated in the same way. It is clear that the continuing use of these remedies stems from blind acceptance of a deep-rooted tradition, the origins of which have now been totally forgotten. Yet the need to explain to their students the reasons for using these substances has led neurologists to grace them with the term 'antispasmodics', and to explain their action somewhat subtly as follows: valeric acid, one of the constituents of valerian, has been named as an active principle and is generally administered in the form of a salt of zinc, coated in sugar so as to mask its unpleasant taste. Some modern authorities who are aware of the origins of this treatment are full of admiration for the fact that people had long ago, despite their misunderstanding of hysteria, been able to discover such a precious method of treatment while at the same time giving an absurd explanation for its action. This persistent rationalisation of a process known however to have been an irrational one in the past is frequently to be observed.[18]

It is in our view very instructive to set this *scientific* page alongside a *literary* one, born of the reverie of a writer both strange and wise. In his novel entitled *In the Bond of the Sea*, Strindberg also claims he can cure hysteria. He is led to use asafoetida after a series of reflections that obviously have no objective meaning and that must be interpreted from a subjective standpoint alone:

> This woman felt sick in body, though without exactly being ill. He therefore composed a series of medicaments, the first of which would force the patient to leave her sick state of mind and spirit and would simply situate the sickness in her body. To this end, he took from the household pharmacopoeia that most offensive of all drugs, asafoetida, and thinking it more fitted than any other to produce a state of general indisposition, he removed a dose of this that would be sufficient to produce real convulsions. That is to say, physical being in its entirety would rise in revolt against this foreign substance, and all the functions of the soul would concentrate their forces so as to repel it. Imaginary sufferings would as a result be forgotten. It would then just be a matter of bringing about transitions, from this one disgusting sensation through other lesser ones until perfect liberation was achieved, moving gradually through a range of refreshing, balsamic, softening, and soothing remedies; it would be a matter of awakening a total feeling of wellbeing, like that following the experience of difficulties and dangers that leave sweet memories. He put on his white cashmere morning coat.[19]

We would like to have the time to psychoanalyse the whole of Strindberg's long narrative which would allow us to study the curious mixture of a subjective a priori and what claim to be objective values. However, affective values are so obvious in this extract that there is no need to underline them. We can therefore see very clearly in both scientists and dreamers the same techniques of demonstrating impure proofs. We cannot urge readers strongly enough to seek out in a systematic way convergences that are scientific, psychological, and literary. The same result is obtained whether by dream or by experience and this in our view is proof that experience is but a dream. By simply bringing in a parallel literary exercise we have already psychoanalysed objective knowledge.

However, the immediate and incorrect rationalisation of an uncertain

phenomenon might well be more visible in simpler examples. Is it true that will-o'-the-wisps disappear around midnight? The fact is explained before being authenticated. In 1780, Saury – a serious author – writes that this disappearance 'is perhaps because it is colder and the exhalations producing (the will-o'-the-wisps) are then too condensed to hold themselves in the air; perhaps they are also stripped of electricity, which prevents them from fermenting and from producing light and makes them fall back to earth'.[20] Do will-o'-the-wisps give chase to the person attempting to flee from them? His answer is as follows: 'This happens because they are pushed forward by the air that comes and fills the space left behind by that person'. In all these imprudent rationalisations, it is plain that the *answer* is much clearer than the *question* or better, that the answer was given before the question was clarified. This perhaps justifies us in saying that the sense of the problem characterises the scientific mind.

Lastly, were it possible for all instances of objective knowledge to take an accurate measurement of empiricism on the one hand and of rationalism on the other, we would be astonished at the immobilisation of knowledge that occurs when particular observations are immediately adhered to. We would see that in common knowledge facts are *too soon* mixed with reasons. There is too short a path from fact to idea. People think they can keep to the facts. They like to say that while mistakes may have been made in the *interpretation* of facts in the past, at least the facts were seen and well seen. Now, if a fact is to be defined and specified there has to be a minimum of interpretation. If this minimum interpretation coincides with a fundamental error, what then remains of the fact? Of course, where a fact is concerned that has, in a way, been extrinsically defined in an area manifestly foreign to its essence, then this weak definition – which does not hold us to anything – may not be erroneous. (It is not sufficiently organic to be so!) For example, if it is a matter of seeing, saying, and repeating that amber attracts light bodies when it is rubbed, then this *mechanical* action, extrinsic as it is to hidden electrical laws, will doubtless provide an opportunity for accurate observation, as long as no *value* is put on the word 'attracts'. Yet this accurate observation will be a closed experience. It is hardly surprising that it has gone from age to age without bearing fruit, and without giving rise to experiences of variation.

VI

We would moreover be committing a serious error if we thought that empirical knowledge could remain at the level of rigorously assertoric knowledge by restricting itself to the simple affirmation of facts. Description never

respects the rules of *healthy banality*. Buffon himself wished this deliberately banal, flat language to be used in scientific books. He prided himself on having a featureless and unadorned style of writing, which left objects to be seen *directly*. Yet this enduring wish for simplicity can come to grief. A word will suddenly reverberate in us and find too lingering an echo in cherished, old ideas; an image will light up and persuade us outright, abruptly, and all at once. In reality, a serious, *weighty* word, a key word, only carries everyday conviction, conviction that stems more from the linguistic past or from the naivety of primary images than from objective truth, as we shall be showing in a later chapter. All description nucleates in this way and collects about centres that are too bright. Unconscious thought gathers around these centres – these nuclei – and thus the mind is introverted and immobilised. Buffon in fact recognised the need to keep minds in uncertainty, so that they could in future come to reflexive knowledge. For him, 'What is essential is to fill people's heads with ideas and facts and, if possible, prevent them from being too quick to reason and make links on this basis'.[21] However, what Buffon has particularly in mind is a lack of information: he does not see the almost immediate deformation of objective knowledge when it is interpreted by the unconscious and gathered around these centres of unconsciousness. He believes that when given too narrow an empirical base, the mind will exhaust itself making 'false combinations'. In reality, the ability to make links does not have its origin in surfaces, in the very place where observations are made, but rather it springs from more inward reactions. Bacon's tables do not refer *directly* to a reality given greater value. It must not be forgotten that before instances are listed they are sought. They are therefore the results of ideas for research, ideas that were to a greater or lesser degree both hidden and given value. Before being taught how to describe objectively, observers should therefore have been psychoanalysed, with repressed irrational explanations being carefully exposed. We only have to read the sections in Buffon's work in which the *object* does not come to the observer's attention naturally and we shall recognise the influence of *pre-scientific concepts with centres of unconsciousness*. This can be best illustrated from his researches into minerals. In particular, a kind of *hierarchy* of minerals can be seen here, in blatant contradiction to claims to be plainly and flatly empirical. We can therefore reread Buffon's *Histoire naturelle* with greater insight, observing the observer and adopting the attitude of a psychoanalyst watching out for irrational reasons. We shall understand that his portraits of animals, bearing as they do the sign of an erroneous biological hierarchy, are full of features that the narrator's unconscious reverie imposes. The lion is the king of the animals because to one who is in favour of order, it appears fitting that all be-

ings, even the beasts, should have a king. The horse remains noble in its servitude because in his social functions, Buffon wishes to remain a great and noble figure.

VII

However, in order to prove that what is most immediate in primary experience is indeed ourselves, our hidden passions and unconscious desires, we shall now study at some length certain reveries to do with matter. We shall endeavour to show their affective basis and their wholly subjective dynamism. In order to do this, we shall be examining what we shall call the *psychologically concrete* character of alchemy. More than any other, alchemical experience is twofold: it is objective and also subjective. It is to subjective verifications, both immediate and direct, that we shall be drawing attention here. We shall thus give a somewhat extended example of the problems to be dealt with by a psychoanalysis of objective knowledge. We shall moreover have the opportunity to return to this topic in subsequent chapters here in order to discern the influence of particular passions in the development of alchemy.

Alchemy has been judged and condemned by chemists and writers alike.

In the nineteenth century, all historians of chemistry were happy to recognise the alchemists' passion for experiment; they paid homage to some of their positive discoveries; they then showed modern chemistry to have slowly come from the alchemists' laboratories. Yet from reading these historians, it would seem that *facts* were established with considerable difficulty *in spite of ideas*, although no reason for or measure of this resistance is ever given. Nineteenth-century chemists, motivated as they were by a positive way of thinking, were led to make a judgement of objective value and this took no account at all of the remarkable psychological cohesion of alchemical culture.

Turning now to literary figures, from Rabelais to Montesquieu their judgement is even more superficial, the alchemist being represented as a disturbed mind in the service of a covetous heart.

Lastly, scholarly history and colourful narratives depict an experience that is doomed to failure. We imagine the alchemist to be as laughable as any loser is. He is for us the unrequited lover of a chimera.

So negative an interpretation should however arouse some misgivings. We ought at least to be surprised that such empty theories have such a long history, continuing to spread even during the development of science and up

to our own day. In point of fact, their persistence in the eighteenth century has not escaped Mornet's perceptive eye. Constantin Bila has written a thesis studying them in action too in eighteenth-century literary life; he sees this though as simply a measure of the adept's credulity and the master's trickery. This study could be pursued however throughout the nineteenth century. The attraction of alchemy would be seen for many a spirit, leading to work as psychologically profound as that of Villiers de l'Isle-Adam. The centre of resistance must therefore lie more hidden than is imagined by *naive rationalism*. Alchemy must have deeper sources in the unconscious.

In order to explain the persistence of alchemical theories, some historians of freemasonry, enamoured as they are of mystery, have described alchemy as a system of political initiation, which was all the more covert and obscure because it appeared to have a more obvious meaning in the work of chemists. Thus, in an interesting article on alchemy and freemasonry Kolpaktchy writes that '*Behind* a purely alchemical (or chemical) facade which was *very real*, there was therefore a no less real initiatory system ... this initiatory system can be found underlying all esoterism in Europe from the eleventh century onwards, and it therefore underlies both Rosicrucian initiation and freemasonry'.

Yet this interpretation remains too intellectualist, even though Kolpaktchy recognises that alchemy is not simply 'a vast mystification intended to dupe ecclesiastical authorities'. It cannot give us a true measure of the psychological resistance put up by the alchemical *obstacle* to the attacks of objective scientific thought.

All these attempts at explanation take no account of the radical *opposition* of chemistry to alchemy. We must therefore now turn to examine deeper psychological conditions in order to explain such powerful, complete, and lasting symbolism. This symbolism could not be passed on in simple allegorical forms if it did not overlay an unquestionable psychological reality. Indeed, broadly speaking, the psychoanalyst Ernest Jones has shown that symbolism is not taught like an objective truth. For it to be taught, symbolism must be attached to symbolising forces that pre-exist in the unconscious. We can say, as Jones does, that 'symbolism has to be re-created afresh out of individual material, and that the stereotypy is due to the uniformity of the human mind in regard to the particular tendencies that furnish the source of symbolism - i.e., to the uniformity of the fundamental and perennial interests of mankind'.[22] It is *against* this stereotypy whose origin is not perceptive but affective that the scientific mind must act.

If we study the alchemists' culture at the very fount of their personal convictions, we shall see this culture to be thought that has been *clearly com-*

pleted and that, throughout the cycle of experiments, receives *psychological* confirmations which make the solidity and inwardness of its symbols very plain. Love for a chimera is, in truth, the most faithful of loves. To fully appreciate the *completeness* of the alchemists' convictions, we must not lose sight of the fact that the philosophical theory that sees science as essentially *incomplete* is a modern one. Modern too is the kind of thought that is always pending, always on hold, that develops from hypotheses long regarded with suspicion and which can always be revoked. In pre-scientific times on the contrary, a hypothesis is based on a deep conviction: it illustrates an inner state of mind and spirit. Thus, *with its scale of symbols, alchemy offers us a reminder of an order of inward meditations*. These are not things and substances that are being put to the test; these are in fact psychological symbols which correspond to things, or to put it better, the different degrees of inward symbolisation whose hierarchy we wish to experience. It seems indeed that in their experience of the world of objects, alchemists 'symbolise' with all their being and with all their soul. For example, having reminded us that ashes always retain the mark of their substantial origin, Becker makes this odd wish (which is moreover still recorded in the *Encyclopédie* in the article entitled 'Ashes'):

> May it please God ... that I have friends who will pay me the last honours; who, I say, will one day convert my bones, dry and worn out by long hours of work, into a diaphanous substance that down all succeeding centuries cannot be changed, that will keep its generic colour, not the greenness of plants but rather the colour of the air of a quivering narcissus; and this they could do in a very few hours.

A historian of positive chemistry may well see this as being above all a more or less clear chemical experiment on calcium phosphate or, as one eighteenth-century writer called it, on 'animal glass'. Becker's wish has, we believe, a different tonality. These dreamers pursue not earthly but spiritual possessions. Unless there is this inversion of interest, we shall form an inaccurate idea of the meaning and depth of the alchemist's way of thinking.

Consequently, if the expected material action failed to take place, this operative accident would not destroy the psychological value of the tension making up this expectation. This unsuccessful *material* experience would be disregarded without any hesitation: the forces of hope would remain intact because those who are acutely conscious of hope have already met with success. This is of course no longer the case where the scientific mind is concerned: here, any *material* failure is at the same time an *intellectual* failure

since even at its most modest, empiricism in science presents itself as being involved in a structure of rational hypotheses. In modern science, a physics experiment is a particular case of a general thought, and a particular moment in a general method. It is free from the need for personal success insofar as it has, in fact, been verified by the scientific community. Science in its entirety does not need to be *put to the test* by the scientist. What happens though when experiment contradicts theory? You can, in that case, keep repeating the negative experiment over and over again, in the belief that it is simply a failed experiment. This is what Michelson did when he so often repeated the experiment which, in his view, should show the immobility of the ether. In the end however, when Michelson's failure was beyond doubt, science had to modify its fundamental principles. Thus was relativity science born.

Should an experiment in alchemy not succeed, the conclusion is drawn quite simply that the right matter or the necessary germs of being were not used or even that the moment has not yet come for it to produce a result. It might almost be said that alchemical experiments develop in Bergsonian duration, in biological and psychological duration. An unfertilised egg will not hatch out; an egg that the hen inadequately or intermittently broods will go bad; a tincture that has grown stale will lose its mordant and its generative force. For it to grow and to produce, there is to every being a season, a concrete and an individual duration. Thus, when we can lay the blame on time that hangs heavy, on surroundings that fail to mature, on delicate growth deep within that grows idle, then we have everything we need in order to explain from within the accidents of experiment.

Yet there is a way of interpreting the material failure of an alchemical experiment that is deeper and more inward still. Here, the experimenter's moral purity is called into question. When the expected phenomenon fails to be produced with the help of the correct symbols, what we have here is not just a failure but rather a psychological flaw, a moral fault. It is the sign of meditation that is insufficiently profound, of psychological slackness and prayer that is insufficiently attentive and fervent. As Hitchcock has so well put it in writings that are too little known, what we are dealing with in the works of the alchemists is not so much experimentation but complication.

How could the alchemist purify matter without purifying his own soul first? How could the worker, as the masters prescribe, enter with all his being into the cycle of the work if he brought to it an impure body, an impure soul, and a covetous heart? It is not uncommon to see an alchemist penning a diatribe against gold. Thus, Philalethe writes: 'I scorn and rightly loathe this idolatry of gold and silver'.[23] And again he says: 'I even have an aversion to gold, silver, and precious stones, not as God's creatures for I respect them as

such, but because they were used in the idolatry of the Israelites as well as in that of all peoples'. In order to succeed with his experiment, the alchemist must often live long periods of austerity. Faust, heretical and depraved as he was, needed a demon's help in order to assuage his passions. An upright heart, an unblemished soul animated by forces of good and reconciling its own nature with that of the universe will, on the contrary, naturally find the truth. Truth will be found in nature because it is experienced in the self. The truth of our heart is the truth of the world. Never were the qualities of self-sacrifice, integrity, patience, scrupulous method, and relentless labour so closely bound together as in the work of alchemists. Nowadays, it seems that those who work in laboratories can detach themselves more easily from their work. Their emotional lives are no longer mixed up with their scientific lives. Their laboratory is no longer at home, in attic or cellar. They leave it in the evening just as one leaves an office, and they go home to their families, to other cares and other joys.

We believe that were we to look at all the advice which abounds in the practice of alchemy and interpret it, as it seems still possible to do, in its objective and subjective ambivalence, we would come to establish a pedagogy that is in some respects more truly human than the purely intellectualist pedagogy of positive science. Indeed, alchemy is on the whole not so much an intellectual initiation but rather a moral one. We must consequently judge it subjectively according to its moral results before we consider it objectively and judge it by the results of its experiments. This aspect has not escaped Hélène Metzger who has this to say about van Helmont: 'This will not seem a strange interpretation of van Helmont's thought if it is remembered that this philosopher considered laboratory work, as well as prayer and fasting, as but preparing the enlightenment of our spirit'.[24] Thus, an anagogic psychoanalysis of the alchemist must be set in place above the materialist interpretation of alchemy.

This spiritual enlightenment and moral initiation do not constitute a mere training course intended to help positive progress to be made in the future. The best themes of moral contemplation and the clearest symbols of a scale of inner perfection are to be found through working, in the slow and gentle handling of matter and the alternation of dissolving and crystallising, like the rhythm of day and night. Nature can be admired in extension, in heaven and earth. And nature can be admired in intension, in its depth and in the play of its mutations of substance. Clearly though, this kind of wonderment, wonderment that goes deep, is bound up with the meditation of an inner life. All the symbols of objective experience can immediately be translated into symbols of subjective culture. How infinitely simple a pure intuition is! The sun plays and laughs on the surface of a pewter vase. Jovial pewter, whose planetary co-ordinate is Jupiter, is as contradictory as a god: it both absorbs and reflects light, its surface being both opaque and polished, bright and dark. Pewter is matter that is dull yet that will suddenly shine very brightly. All we need for this to happen is a ray of sunshine in the right place, light drawn to it in friendship, and the pewter will be revealed. As Koyré has so perceptively said in a book to which we must constantly return in order to understand the intuitive and fascinating character of symbolic thought, for someone like Jacob Boehme this is 'the true symbol of God, of that divine light that needed *another*, that needed resistance and opposition in order to reveal itself and make itself manifest; that, in short, needed the world in order to be reflected and expressed there, to set itself against it and to leave it'.

If contemplating a mere object – a vase that by chance catches the rays of the setting sun – offers us so much enlightenment about God and our own soul, then how much more detailed and evocative will be the contemplation of successive phenomena in the precise experiments of alchemical transmutation. This leads us to understand the deduction of symbols as no longer a process of logic or experiment but rather as occurring at a deep and personal level. It is not so much a matter of *proving* but of *experiencing*. Who will ever know what spiritual rebirth is and the purifying power of all rebirth unless they have dissolved a coarse salt in its right mercury and then made it anew by patient, methodical crystallisation, watching with anxious heart for the first shimmering of crystal? Recovering the object means in fact recovering the subject: the self is recovered through a rebirth of matter. Matter lay in the palm of our hand. To make it purer and more beautiful, we plunged it into the treacherous heart of acids, risking what we possessed. One day the acid, sweeter then and softened, gave back the crystal. Our whole soul celebrates the return of the prodigal son. The psychoanalyst Herbert Silberer has shed considerable light on the moral value of the different alchemical symbols. What strikes us particularly is that all alchemical experiments can be interpreted in two ways, in either chemical or moral terms. A question arises however. Where is the gold? In matter or in the heart? How then can we be unsure of the value dominating alchemical culture? When writers depict the alchemist as seeking his fortune they are offering an interpretation that is psychologically nonsensical. Alchemy's culture is inward. Its first lesson in magic is found deep within the subject, in experience that is *psychologically concrete*. When alchemists then go on to understand nature as operating magically, this is because their own innermost experience is being applied to the world. It is in the soul's magic, where innermost being experiences its own

ascension, that we have the key to understanding how value comes to be actively given to substances that are initially impure and tainted. Silberer mentions an alchemist who recalls that he only made real progress in his art when he noticed that nature works magically. This though is something that is discovered later on; it is a discovery that must be morally deserved if it is to dazzle experience, after having first dazzled our spirit.

This magic is not thaumaturgy. The letter does not rule the spirit. One must believe with the heart, not with the lips. It may be easy to poke fun at the kabbalistic words murmured as the experiment is performed yet this is in fact to misunderstand the psychological experience accompanying material experience, that is to say the experiment on matter. The experimenter gives his all, giving himself first and foremost. Silberer also notes that 'what is to be sown in new earth is usually called Love'. Alchemy prevailed at a time when humans loved nature more than they used it. The word 'Love' here is crucial. It is the password between the work and the worker. Without gentleness, without love, the psychology of children cannot be studied. And in exactly the same way, the birth and conduct of chemical substances cannot be studied without gentleness, without love. Burning with tender love is not really an image for someone who has warmed mercury over a gentle flame. In slowness, gentleness, and hope we have the hidden force of moral perfection and of material transmutation. As Hitchcock has said, 'The great effect of Love is to turn all things into its own nature, which is all goodness, sweetness and perfection. This is that Divine power which turns water into wine; sorrow and anguish into exulting and triumphant joy'.[25] If we accept these images of a love that is more sacred than profane, it will no longer be a matter of surprise that the Bible was constantly consulted in alchemists' laboratories. It would not be hard to find thousands of examples in the books of the Prophets in which lead, earth, gold, and salt speak of human virtues and vices. Alchemy often did no more than codify this homology. Indeed, all the degrees of magical and material transmutation are for some people homologous to the degrees of mystical contemplation:

> In Johannes Daustenius's *Rosarium*, the seven degrees are the subject of the following description. 'In this way, the body (1) causes the water to be conserved. The water (2) causes the oil to be conserved and not to catch alight above the fire. And the oil (3) causes the tincture to be fixed, and the tincture (4) causes the colours to appear, and the colour (5) causes the whiteness to be shown; the whiteness (6) causes all fleeting things (7) to be fixed and to cease to be fleeting'. Exactly the same thing happens in Bonadventure's description of the *septem gradus contemplationis*, and when David of Augsburg outlines the seven stages of prayer. Boehme is familiar with seven Quellgeister.[26]

These homologous scales show fairly clearly that the idea of *value* is associated with the successive products of alchemical experiments. We shall have many opportunities later on for showing that *in the order of objective knowledge, any valorisation must give rise to a psychoanalysis*. This will be one of the main themes of this book. All we need note at present though is the directness and immediacy of this valorisation. What constitutes it is the passionate espousal of primary ideas, ideas that find but pretexts in the objective world.

Our intention in this lengthy section has been to bring together all the psychological characteristics and the more or less objective pretexts of alchemical culture. If we take them altogether as a body, we can in fact form a very good idea of what is *too concrete*, too intuitive, and too personal in the pre-scientific manner of thinking. Teachers must therefore always aim to detach observers from their objects and to shield pupils from the great mass of affectivity centred on certain phenomena that are too quickly symbolised and also, in a way, *too interesting*. This kind of approach is not perhaps as outdated as at first sight it may seem. In my own chemistry classes, I sometimes had occasion to consider the *whiff of alchemy* still eddying about young minds. For example, when one winter morning I was making ammonium amalgam – ammonium butter, as my old teacher used to call it – and working the swelling mercury, I could read the passions present in all those attentive eyes. This interest in everything that swells and grows, that is worked and kneaded, made me think back to the ancient words of Eirenaeus Philalèthe: 'Rejoice therefore if you see your matter swell as if it were dough; for the spirit of life is enclosed therein and will, in due time and if God permits, restore life to the bodies of the dead'. It also seemed to me that the class was all the happier with nature's little story if it had a happy ending, with the mercury the children loved so well being given back its natural aspect and its initial mystery.

Thus, whether in today's chemistry classroom or in the alchemist's workshop, pupil and adept are not at first pure minds. For them, matter itself is not sufficient reason for calm objectivity. We are drawn to the spectacle of the most interesting and most striking phenomena, naturally drawn there with all our desires and passions and with all our soul. It is not surprising therefore that our first objective knowledge should be a first mistake.

NOTES

1 Bachelard does not specify the translation he uses; my translation here.

2 Bachelard's footnote: Claude Comiers, *La Nature et présage des Comètes. Ouvrage mathématique, physique, et historique, enrichi des prophéties des derniers siècles, et de la fabrique des grandes lunettes* (Lyon: 1665).

3 Félix Vicq d'Azyr (1748-94) was a doctor and the author of the first works on comparative anatomy.

4 Bachelard is playing with different senses of 'regular', exploiting in particular its ecclesiastical sense (being subject to a rule, belonging to a religious order) where 'regular' is the opposite of 'secular', hence his phrase 'pre-scientific thought lives in the world'.

5 Bachelard's unspecified reference is to Daniel Mornet, *La Pensée française au XVIIIe siècle* (Paris: Colin, 1926).

6 Joseph Priestley, *The History and Present State of Electricity with Original Experiments* (London: 1767). All quotations from Priestley are taken from the original English text, of which there were several editions; Bachelard quotes from the French translation (Paris: 1771).

7 This quotation is from Priestley.

8 Bachelard gives his source here as the article on 'Diamonds' in the *Encyclopédie*. See note 12.

9 Bachelard's footnote: Alexandre Volta, *Lettres*, trans. Osorbier (1778).

10 Bachelard's footnote: Régis Messac, *Micromégas* (Nîmes: 1935), 20.

11 Bachelard's footnote: Tibère Cavallo, *Traité complet d'électricité*, trans (Paris: 1785).

12 The *Encyclopédie* to which Bachelard frequently refers in the course of this book was one of the major works of the French Enlightenment. Published in 28 volumes (1751-1772) under the direction of d'Alembert and Diderot, its full title was *Encyclopédie ou Dictionnaire raisonné des sciences, des arts, et des métiers*, its aim being to give an account of the progress of knowledge and thought in all fields.

13 Bachelard's footnote: Carra, *Nouveaux Principes de Physique*, dedicated to the Royal Prince of Prussia, 4 vols. (1781-82).

14 Bachelard's footnote: De Marivetz and Goussier, *Physique du Monde*, 9 vols. (Paris: 1780).

15 Bachelard does not specify the translation he uses; similarly, he omits the source of the following quotation from Devaux.

16 Bachelard's footnote: Édouard Le Roy, 'Science et philosophie', *Revue de Métaphysique et de Morale* (1899).

17 Bachelard's footnote: Rev. Father Castel, Jesuit, *L'Optique des couleurs, fondée sur les simples observations, et tournée surtout à la pratique de la Peinture, de la Teinture et des autres Arts coloristes* (Paris: 1740).

18 My translation, the English edition of Bachelard's French source not having been located. Asafoetida is a resinous, unpleasant-smelling gum exuded from the stem of the plant *ferula foetida*; it is an antispasmodic and was formerly used medicinally to treat hysteria.

19 Bachelard quotes the French translation, entitled *Axel Borg*, of Strindberg's novel *I Hafsbandet*, but gives no details of publication or page references.

20 Bachelard's footnote: Saury, Doctor of Medicine, *Précis de Physique*, 2 vols. (Paris: 1780).

21 Bachelard's footnote: Buffon, *Oeuvres complètes*, Year 7. This reference uses the republican calendar, which dated the year 1 from 22 September 1792, the day on which the French monarchy was abolished.

22 Ernest Jones, *Papers on Psycho-analysis*, (London: Maresfield Reprints, H. Karnac (Books) Ltd, 1977), 98. Bachelard uses the French translation here. The context of this quotation is Jones's rejection of Jungian archetypes; Bachelard omits the first phrase 'I adhere to the contrary view (i.e. to Jung's view) that symbolism ...'

23 Bachelard's footnote: Anonymous, *Histoire de la philosophie hermétique, avec le véritable Philalèthe*, 3 vols. (Paris: 1742). Bachelard's subsequent references to Philalèthe – a major alchemical work – are to this text.

24 Bachelard's footnote: Hélène Metzger, *Les Doctrines chimiques en France, du début du XVIIe à la fin du XVIIIe siècle* (Paris: Presses Universitaires de France, 1923), 174.

25 While Bachelard quotes Hitchcock in French, his footnote refers to the original English text: Hitchcock, *Remarks upon Alchemy and the Alchemists* (Boston: 1857). The quotation given here is from Hitchcock's text.

26 Bachelard does not indicate the source of this quotation.

Chapter Three

General knowledge as an obstacle to scientific knowledge

I

The progress of scientific knowledge has been slowed down by one factor above all: we refer here to the false doctrine of the *general* which prevailed from Aristotle up to and including Bacon, and which is still widely regarded as being fundamental to science. Eavesdrop for a moment on philosophers who are talking about science among themselves. You will very soon get the impression that Ernst Mach was being mischievous when he answered William James's 'Every scientist has his philosophy' by observing conversely that 'Every philosopher has his own science'. We would prefer to put it like this: philosophy has a science that is peculiar to itself, the science of generality. We shall endeavour to show that this science of the general is always a halting of experience, a failure of inventive empiricism. When we know the general phenomenon and use it in order to understand all things are we not, as Mallarmé has said in his *Divagations* with reference to a different kind of decadence, 'delighting as the mob does in the myth that is in all banality'? There is indeed a dangerous intellectual delight in rapid, easy generalisation. A psychoanalysis of objective knowledge must carefully examine all the seductive charms of *facility*. Only in this way will we arrive at a theory of truly healthy, truly dynamic scientific abstraction.

Let us begin by taking an example that will clearly show the immobility of summaries that are too general. In order to show in a simple way how inductive reasoning based on a collection of particular facts leads to a general scientific law, philosophy teachers will very often give a quick description of how different bodies fall and then draw the conclusion that all bodies fall. And in order to excuse themselves for such banality, they make out that an example like this shows they have everything they need to indicate decisive progress in scientific thought. Indeed if we compare modern thought with Aristotelian thought here, the former is seen as rectified generality, as amplified generality. Aristotle taught that light bodies – smoke and vapour, fire and flame – returned to their natural abode in the empyrean, while *heavy* bodies *naturally* sought the earth. Our philosophy teachers take the opposite view and say that all bodies fall, *without exception*. And this, they believe, gives us the sound theory of gravitation.

Indeed generality does have a place here, which is why we have begun with this example so as to sharpen our polemic. The contest will be easier later on when we shall show that any rapid search for the general most often leads to misplaced generalities which have no connection with the phenomenon's essential mathematical functions. Let us begin then with the hardest argument.

According to our opponents, according to philosophers, the greatest generalities should be made the basis of scientific culture. The basis of mechanics is that all bodies fall. In optics, it is that all light rays are propagated in a straight line. And in biology, it is that all living beings are mortal. Thus at the threshold of every science great first truths would be set in place, intangible definitions that shed light on a whole theory. The opening paragraphs of pre-scientific books are in fact cluttered up with these attempts at preliminary definition, as we can see in eighteenth-century physics and twentieth-century sociology alike. And yet the question can be raised as to whether these great laws constitute truly scientific thoughts or, what amounts to the same thing in our eyes, thoughts that suggest other thoughts.

If we assess the epistemological value of these great truths by comparing them with the inaccurate knowledge they replaced, there is no doubt that these general laws have been effective. Yet they are no longer so. It is for this reason that the stages children go through in the classroom are not homologous with historical stages. It can indeed be seen that general laws such as these now *block* thought. They give their answers with one voice or rather they answer without any question being asked, for the Aristotelian *question* lapsed into silence long ago. What makes this over-prompt reply so very attractive is this: for the pre-scientific mind, the verb 'to fall' is sufficiently descriptive; it gives the *essence* of the phenomenon of falling. In fact, as has often been said, these general laws define words rather than things. The general law of the fall of heavy bodies defines the word *heavy*. The general law of the straightness of light rays defines both the word *straight* and the word *ray*, the ambiguity of the a priori and the a posteriori here being such that we personally suffer from a kind of logical vertigo. The general law of the growth and death of living beings defines the word *life* pleonastically, in effect. Everything is clear, therefore; everything has been *identified*. In our view how-

ever, the shorter the process of identification, the poorer is experimental thought.

Teaching methods are evidence of the inertia of thought that has just found satisfaction in the verbal agreement of definitions. To show this, let us follow for a moment the lesson in elementary mechanics that studies falling bodies. It has just been said that all bodies fall, without any exception. By doing the experiment in a vacuum, with the help of a Newtonian tube, we can arrive at a richer law: *in a vacuum, all bodies fall with the same velocity*. We now have a useful statement, which is a real basis for an accurate empiricism. However, this well constituted general form may bring thought to a standstill. In junior classes in our secondary schools, this law is in fact the stage where weary minds come to a halt. This law is so clear, so complete, and so closed in on itself that no one feels the need to make a closer study of falling. Generalising thought is satisfied and as a result, the experiment has lost its incentive. When it comes to studying just the throwing of a stone vertically up in the air, we immediately get the impression that the elements of this analysis are lacking. We cannot distinguish between the force of gravity acting positively in the downward movement and the force of gravity acting negatively in the upward movement. When knowledge is too general, the area of the unknown surrounding it cannot be resolved into precise problems.

To sum up then, even when a cycle of *exact ideas* is being followed, we realise that generality immobilises thought and that the variables describing the general aspect cast a shadow on the essential mathematical variables. Broadly speaking, the idea of velocity here conceals that of acceleration. It is however the idea of acceleration that corresponds to the dominant reality. Thus, the mathematics of phenomena is itself organised in a hierarchy and the first mathematical *form* is not always the correct one, nor is it always the first form that is really formative.

II

Our remarks will perhaps seem more convincing however if we examine the many instances in which *generality* is obviously misplaced. This is nearly always the case for initial generalities, for generalities designated by *tables* of natural observation that have been drawn up by a kind of automatic recording from sense *data*. In fact, the idea of a *table* does seem to be a constituent idea of classical empiricism and is at the root of a very static kind of knowledge that sooner or later hinders scientific research. Whatever we may think of the obviously greater value of the table of degrees or of the

method of concomitant variations, it must not be forgotten that these methods, which have doubtless gained a certain dynamism, are still dependent on the table of presence. What is more, there is always a tendency to come back to the table of presence and eliminate disturbance, variation, and anomaly. It so happens that one of the most striking aspects of modern physics is that it works almost uniquely in the area of *perturbation*. It is perturbation that now poses the most interesting problems. In short, there always comes a time when the first tables of empirical law have to be broken.

It would be all too easy to show that once empirical thought began to progress, all the general facts isolated by Bacon were seen to be unfounded. In passing judgement on Baconism, Liebig may have been impassioned but he was also fundamentally just. We shall only refer to one passage in Liebig's short book where he offers an *interpretation* of Baconian method in terms of Bacon's chief preoccupations. The inversion of *explanatory values* that Liebig points out seems in our view to come within the province of a real psychoanalysis:

> Bacon's method ceases to be incomprehensible when we remember that he is a lawyer and a judge, and that he consequently applies to nature the methods of a civil and criminal inquiry.
>
> From this standpoint, his division into *Instances* and the relative values he gives them can immediately be understood; these are witnesses he is hearing and on whose depositions he bases his judgement ... With reference here to heat, this then is more or less how Bacon reasons in accordance with his lawyer's habits.
>
> Nothing can be done with the heat of the sun because of the presence of perpetual snows on high mountains, though they be close to the sun ... The heat of feathers, of wool, and of horse dung are all related to animal heat, the origin of which is very mysterious (Bacon will not therefore waste his time looking in that direction) ... As iron does not *expand* under the action of a very high temperature (this, it seems, is one of Bacon's assertions) and as boiling water is very hot without being luminous, this permits a judgement of alibi to be made against the phenomena of expansion and light. The senses can deceive us where heat is concerned since warm water seems hot to a cold hand and a hot hand can find the same water to be cold. Taste is even less conclusive. Vitriol *burns* fabric but when diluted in water it has an acid taste and does not give the tongue a sensation of heat; *spiritus origani* has a burning taste but does not burn the hand. There therefore only remains what the eye sees and the ear hears, that is to say both the flickering and the inner movement of the flame and the murmur

> of boiling water. These admissions can be reinforced by torture, the torture of the bellows with whose aid the flame's agitation and movement grow so violent that the sound it makes is just like that of boiling water. If we finally add to this the pressure exerted by a foot that stamps out all that remains of heat, then pursued in this way by the judge, this unfortunate heat is forced to admit that it is an unquiet being, turbulent and fatal for the civil existence of all bodies'.[1]

In the end, the constitution of a table only *generalises* a particular intuition, which is given increased value by a tendentious inquiry.

Without spending any more time on Bacon and with a view to showing the harmful influence of Baconism some hundred and fifty years after his death, let us give just one example where the use of tables of presence and absence led to nonsensical assertions. In 1786, the Abbé Bertholon, an important writer who was professor of experimental physics to the States-General of the Languedoc and a member of ten or so provincial Royal Societies and of a number of learned societies in other countries, says this: 'Milton's genius shone from September until the spring equinox, a time when the electricity in the air is more abundant and continual, and for the rest of the year Milton could no longer be found in Milton himself'.[2] It can immediately be seen how, if such a table were taken as our basis, an electrical theory of genius will come to be developed. The Abbé Bertholon, aided in this by Montesquieu, is not of course slow to see the diversity of national characteristics as dependent on variations in atmospheric electricity. It must indeed be stressed that when eighteenth-century physicists make use of such a method, they consider themselves to be cautious. The Abbé Bertholon says in passing that 'In physics as in trigonometry, we must establish a sure basis for all our operations'. Does the use of Bacon's tables really give an initial triangulation that can serve as the basis for a description of reality? It hardly seems so when one reads the detail of the Abbé Bertholon's books.

However, rather than adopting too wide a frame of reference, we shall study a number of false concepts in science that were formed when phenomena were examined empirically and in nature. We shall see the effect of these false concepts in seventeenth and eighteenth-century culture. We shall also make the most of every opportunity to show the almost natural formation of false tables. Our condemnation of Baconism will therefore be from a psychological point of view here, and historical conditions will not come into it.

III

Before presenting our examples, it is perhaps desirable that we should briefly indicate what we consider to be the real attitude of modern scientific thought in the formation of concepts. The sclerosis of concepts formed by Baconian method will then be clearer.

As we said in our first chapter here, the scientific mind can go astray if it follows two contrary tendencies, the attraction of the singular and that of the universal. Where conceptualisation is concerned, we shall define these two tendencies as characteristic of knowledge in intension and in extension. Yet if the intension and extension of a concept can each lead to an epistemological halt, then where are the sources of the mind's movement to be found? How can scientific thought recover and find a way out of this situation?

We need to create a new word here, between intension and extension, in order to refer to this activity of inventive empirical thought. This word would have to be given a very particular dynamic sense. Indeed, in our view the richness of a scientific concept is measured in terms of its power of deformation. This richness cannot be attached to an isolated phenomenon that would be regarded as growing increasingly rich in characteristics, and therefore ever richer in intension. Nor can this richness be attached to a collection that would bring together the most heterogeneous phenomena and extend in a *contingent way* to new cases. An intermediate meaning will be achieved if enrichment in extension becomes *necessary*, and as co-ordinated as richness in intension. In order to include new experimental proofs, we must then *deform* our initial concepts, examine these concepts' conditions of application, and above all incorporate *a concept's conditions of application into the very meaning of the concept*. In this last requirement we have, in our view, the chief characteristic of the new rationalism, corresponding to a strong union of experiment and reason. The traditional division that separated a theory from its application was unaware of this need to incorporate the conditions of application into the very essence of the theory.

Since application is subject to successive approximations, it can be said that the scientific concept corresponding to a particular phenomenon is the *group* of successive and well-ordered approximations. Conceptualisation in science needs a series of concepts that are being perfected in order for it to have the dynamism we are aiming at and for it to form an axis of inventive thoughts.

Conceptualisation of this kind totalises the history of the concept and actualises it. Beyond history and driven forward by history, it gives rise to experiments deforming a historical stage of the concept. What it seeks in

experiment is opportunities for *complicating* the concept, for *applying* it despite the concept's resistance, and for realising the conditions of application that reality did not bring together. It is then that we understand that science *realises* its objects without ever just finding them ready-made. Phenomenotechnique *extends* phenomenology. A concept becomes scientific in so far as it becomes a technique, in so far as it is accompanied by a technique that realises. We are therefore very conscious that the problem of modern scientific thought is once again a problem that is philosophically intermediate. As in Abelard's time, we would like to take up an intermediate position between realists and nominalists, positivists and formalists, between advocates of facts and of signs. We are therefore laying ourselves open to criticism on all sides.

IV

In contrast to this brief outline of a theory of proliferating concepts, let us now give two examples of conceptual sclerosis, of concepts formed when general knowledge is too readily espoused. These two examples concern *coagulation* and *fermentation.*

The very particular phenomenon of coagulation will show us how a bad way of reflecting on generality comes to be constituted. In 1669, the *Académie des sciences* proposes a study of the general fact of coagulation, in the following terms:

> It does not fall to everyone to be surprised that milk curdles. This is not in any way a strange experience ... it is so unexceptional that it is almost regarded as insignificant. However, a Philosopher can find much to reflect on here; the more it is examined, the more wondrous it becomes and it is science that is then the mother of wonderment. The *Académie* did not therefore consider it a matter unworthy of itself to study how coagulation takes place; it wished though to consider all the different kinds of coagulation in order to gain more enlightenment from comparing them with one another.[3]

The Baconian ideal is sufficiently clear here for us not to have to dwell on it. We shall therefore see the most diverse and heterogeneous phenomena coming together under the heading of coagulation. Among these phenomena, the complex products derived from animal economy will, as is often the case, be our first teachers. This is one of the characteristics of the *animist obstacle* that we would just like to point out here before returning to it later on. The *Académie des sciences* therefore studies coagulation with reference

to milk, blood, bile, and fats. Fats stick to our plates and so cooling down is a fairly visible cause of coagulation. The *Académie* will therefore study the solidification of molten metals. Next, they see the congelation – or freezing – of water as a kind of coagulation. This movement from one thing to another takes place so naturally and so easily that we cannot fail to see the persuasive action of language here. From coagulation, we slide imperceptibly into congelation.

In order to gain better knowledge of natural congelations, it is considered 'fitting to consider some of these that are produced by art'. Du Clos recalls – though without vouching for it – that 'Glauber speaks of a certain salt that has the virtue of freezing into ice not just ordinary water but the aquosity of oils, wine, beer, brandy, vinegar etc.. it can even reduce wood to stone'. This reference to unspecified experiments is very typical of the pre-scientific mind. It is in fact the mark of the odious collusion of erudition and science, of opinion and experiment.

Now though we come to the extreme of generality, that pedantic generality which is so clearly typical of thought that preens itself. 'When the sap in trees becomes bark and the chyle in animals takes on the solidity of their limbs, this takes place by means of a kind of coagulation. This is the most extensive of all coagulations and can, according to du Clos be called transmutative'. It can be seen that the very worst mistakes occur in the area of maximum extension.

The starting-point here then was organic liquids. After making a detour into the inanimate world we come back to organic phenomena, which is clear proof that no progress has been made, that the problem has not been made more specific and conceptual forms have not been ordered. Moreover, this example shows the damage done when the principle of identity is too quickly applied. It is permissible to say that when the *Académie* applied the principle of identity with such ease to disparate facts that were specified to a greater or lesser degree, it *understood* the phenomenon of coagulation. However, it has also to be said straightaway that this kind of *understanding* is antiscientific.

Conversely, once the phenomenal unity of coagulation has been so freely constituted, any proposal of making subsequent diversifications will be met with great wariness. In this wariness of variation and this lazy reluctance to make distinctions we see in fact the characteristics of conceptual sclerosis. For example, the following proposition, so typical of identification by general aspect, will henceforward be the starting-point: 'What is more similar than milk and blood?' And when a slight difference is found between these two liquids where coagulation is concerned, it is not thought necessary to

linger over it: 'determining the nature of this quality is a detail and a particularity into which we cannot really enter'. Such disdain for detail and such scorn for particularity show pretty clearly that pre-scientific thought has shut itself into general knowledge and wishes to remain there. Thus, with its 'experiments' on coagulation, the *Académie des sciences* put a stop to productive research. It did not give rise to any well-defined scientific problem.

After this, coagulation is often taken to be a means of universal explanation for cosmogonic problems. A very curious tendency leading imperceptibly from explanation by the general to explanation by the large could be examined here. This is a tendency that Albert Rivaud has pointed out with great subtlety when he showed that in mythological explanation, what is principle is the *Ocean* and not the *water*, as is most often claimed.[4] In a book translated into French in 1780, Wallerius makes coagulation a motif of cosmogonic explanation, as follows:

> The waters (have) a fairly strong tendency to coagulate with other materials and to come together in a solid body ... Water's disposition to solidity can again be observed in foam which is stirred up by movement alone. Foam is much less fluid than water since it can be picked up with our hands ... Therefore, movement alone changes water into a solid body.[5]

There follow many pages describing the various processes of water's coagulation. According to this celebrated geologist, coagulation suffices to explain the formation of animals: 'Everyone knows moreover that animals come from a liquid matter which becomes solid through a kind of coagulation'. Thus, we see once again here the primary intuition of the preceding century. And in order to be completely convincing concerning the generic action of the coagulating principle, Wallerius quotes Job: '*Instar lactis me mulxisti, et instar casei coagulari permisisti*'.[6]

Many are the alchemists too who have dreamed over coagulation. In 1722, Crosset de la Heaumerie writes that 'It is no harder for a hermetic Philosopher to fix quicksilver than for a simple shepherdess to coagulate milk to make cheese .. It is no harder to turn quicksilver into real silver using seeds of silver than it is to thicken milk into cheese using rennet, which is digested milk'.[7]

In both geologist and alchemist, the symbol of coagulation can be seen to gather to it animist themes of greater and lesser purity: the ideas of seed and leaven are active in the unconscious. With these ideas of growth that is animate and alive, a new *value* appears. As we shall often have occasion to point out, any trace of *valorisation* is a bad sign in knowledge that is aiming

at objectivity. A value here is the mark of an unconscious preference.

As we shall also often be pointing out, as soon as a value intervenes you can of course be sure of finding oppositions to that value. Value automatically produces attraction or repulsion. Counter to the intuition that imagines coagulation to be the action of a germ or leaven producing or strengthening life is one that, without any more proof, sees it as the sign of death. Thus in 1622, Blaise de Vigenère writes in his *Traité du feu et du sel* that 'Every coagulation is a kind of death, and all liqueousness a kind of life'. This valorisation is of course no better than the first. A psychoanalysis of objective knowledge must resist all valorisation. It must not only transmute all values but also radically devalorise scientific culture.

To show the difference between the scientific mind and the more or less value-giving pre-scientific mind, all we need to do where the concept under discussion is concerned is look at some contemporary studies of colloids and gels. As Liebig has said, modern scientists seek to limit their experimental field rather than to multiply instances. Once in possession of a clearly defined phenomenon, they seek to determine its variations. These phenomenological variations indicate the phenomenon's mathematical variables. The mathematical variables are intuitively brought together in curves, brought together as functions. Reasons for variation may appear in this mathematical coordination, reasons that remain sluggish, lifeless or degenerate in the phenomenon under consideration. Physicists will try to provoke these reasons. They will try to *complete* the phenomenon, to *realise* certain possibilities that the mathematical study has revealed. In short, contemporary scientists base themselves on a *mathematical understanding* of the phenomenal concept and strive to make reason and experiment equal here. Their attention is held not by the general phenomenon but by one that is organic and hierarchical, that bears the mark of an essence and a form and is, as such, permeable to mathematical thought.

V

We also wish to study from the same standpoint a better defined and more important concept, coming closer here to modern times. In order to attain our critical aim, we must in fact look at concepts that are both correct and useful, and show that they can constitute an *obstacle* by offering thought a general form which is premature. We shall thus study the concept of *fermentation* by making reference to an important writer who devoted himself to the new way of thinking, that is to say to David MacBride. His book has as

its epigraph this phrase of Newton's: 'The main business of natural philosophy is to argue from phaenomena without feigning hypotheses'.[8] We shall see though how serenely what are called experimental views refer in fact to entirely hypothetical intuitions.

To begin with, MacBride retains the following definition by Macquer, considering it both accurate and clear: fermentation is 'intestine motion, which arising spontaneously among the insensible parts of a body, produceth a new disposition, and a different combination of those parts'.

In accordance with this definition, fermentation affects both the animal and the vegetable kingdoms; digestion is a favoured example of it. And so we see this writer dealing with *first* experiments, with experiments that ostensibly precede hypotheses: mixtures are made of bread and water, and of bread, mutton, and water. For the pre-scientific mind, this kind of mixture no doubt gives a *complete* phenomenon that unites the three realms of nature in the same vessel. Need we stress how greatly this completeness, in the sense of an extensive sum, differs from the completeness, in the sense of intensive coherence, to which we have already referred here as being one of the distinctive features of contemporary physico-mathematical thought?

To this last mixture will be added either lemon, spinach, watercress, saliva, honey, or brandy in order to vary the experiment. A record will then be kept of internal movements. Smells will also be noted and these phenomena will often be referred to in terms of their relation to the smell of cheese or fenugreek. The link between pre-scientific knowledge and ordinary knowledge is therefore both close and strong. Moreover, this objective study will unfailingly be compared with the entirely inward experience of digestion, and fermentation will in fact be explained as a *digestion.* Is not the *internal* movement within the stomach 'caused by the gentle warmth of that place, by what remains of the last meal taken, and by the fermentative virtue of saliva and gastric juice'? Let us note in passing the influence ascribed to the remains of the last meal. These serve as a real kind of *leaven* which, from one digestion to the next, has the same role as the leftover dough the housewife keeps back in her kneading-trough so as to preserve the virtues of bread-making from one batch to the next.

This comparison between fermentation and digestion is not fortuitous. It is fundamental and continues to direct research, making very clear therefore the gravity of the inversion performed by the pre-scientific mind when it places the phenomena of life at the root of certain chemical phenomena. Thus, MacBride notes that after a good meal it is vegetable or plant foodstuffs that repeat, just as lemon or onion had done in mixtures previously studied in vitro. We see moreover how close the different areas of phenom-

enology are to one another. Pre-scientific thought does not set limits to its object: no sooner has it performed a particular experiment than it seeks to generalise it in the most diverse of domains.

A highly distinctive feature of utilitarian pre-positivism can be seen in remarks like this: given the acid fermentation of milk in the stomach, it is desirable to speed up its digestion, and as digestion is essentially movement Dr MacBride comes to advise 'the tossing and exercise of infants at the breast'. When shaking a flask, does one not in fact activate mixtures and fermentations? Infants should therefore be shaken after each feed.

This is an example of how pre-scientific thought works: it shows very clearly that in moving from preliminary definitions that are too general to the utilitarian conclusions of experiment, pre-scientific thought follows what is in fact a circular path. Had MacBride not arbitrarily defined fermentation as an internal *movement*, he would not have come to offer this odd piece of advice, namely that infants at the breast should be shaken so that they will digest their mother's milk better. The first intuition has not shifted; experiment has not rectified the first hypothesis; the *general* aspect that was grasped at the outset has remained the one and only attribute of the immobile concept.

Furthermore, MacBride's book is very symptomatic in its over-all plan which shows a need for unlimited generality. By studies of *animal* and *vegetable* substances, MacBride sets out in effect to prove that the *fixed air*' is the principle of their cohesion and of their substantial unity. This fixed air is the '*vinculum*' (the chain) or the '*gluten verum*' (the real glue). Having studied meat and vegetables at some length and observed that all these organic substances became *soft* after fermentation, thus losing, he believed, the fixed air that made them cohesive, MacBride then came to examine the mineral kingdom. His study of the mineral kingdom – a succinct study in fact – is therefore undertaken on the basis of very vague and *very general* intuitions that come from both the animal and the vegetable kingdoms. This is again a very typical inversion that we shall be systematically studying in our chapter on the animist obstacle. It is an inversion that shows how very difficult it is to establish the classification of objective thoughts by their increasing complexity.

Trusting in his general intuitions, MacBride comments on the chemical action of carbon dioxide (the fixed air) on slaked lime and sees it in terms of 'cohesion'. What we have here is simply loss of movement, a phenomenon that is the opposite of fermentation. The explanation of phenomena oscillates therefore between two poles, that of *movement and freedom* on the one hand and of *repose and cohesion* on the other, always remaining at the

level of the immediate data of intuition. The salient quality – cohesion or division – is therefore the generality that suffices to explain all things. *It is generality that we explain and it is by means of generality that we explain*, in the unending circle of early empiricism. And this naive kind of explanation is easily astonished. 'And it was highly pleasing', MacBride writes, 'to see the particles of the quick-lime, which, but two or three minutes before, were quite invisible, and dissolved in the water, all running together, and falling to the bottom, having returned to their original state of insolubility, the moment they were saturated with the fixed air'. The lime had rediscovered 'its cementing principle'. What MacBride finds *pleasing* here, in what is simply a precipitate, is surely just its ready confirmation of his hypotheses. In another experiment, we watch the opposite 'dissolution' of meat where the gases produced by this putrefaction are passed into the solution of lime-water. MacBride then draws a clear conclusion: 'And here we have an additional proof of the *fixed air*'s being the cementing principle in animal substances; since we see, that while the flesh is resolved, and falls in pieces, from the loss of this principle, the lime is rendered solid by having it restored'. It is indeed the general and very weak idea of *solidity* that lies behind this explanation.

This then is an example of a set of observations, both *accurate and precious*, that allow us to solve the false problem of the cohesion and dissolution of meat and do no more than bring in false ideas. Indeed, the intuitive theme of cohesion and solidity is a far too general one. It belongs to naive intuition alone, and is a major theme in pre-scientific explanation.

Moreover, the relation between word and concept here is a very remarkable one. In the words 'fixed air' there is already the supposition of a kind of air that is, to quote Hales, 'bereft of its elasticity and reduced to a state of fixity and attraction'.[10] We should not be surprised then that the *fixed air* fixes. Many examples can be found which show the pre-scientific mind collecting experiments together in terms of what is in the end etymology, by simply assembling words belonging to the same family. Fixed air finds too general a name in the particular experiment in which carbon dioxide acts on lime-water. Its function is then generalised in the excessive way we have just seen.

It must be emphasised that MacBride was not one of those worthless writers who do no more than copy down experiments performed by others. He was a good observer and was often ingenious and perceptive. His researches were reported in the nineteenth-century continuation by Magdeleine de Saint-Agy of Cuvier's *Histoire des sciences naturelles*. Saint-Agy also says that 'MacBride's experiments played a greater part than Black's in turning the attention of physicists and chemists towards the study of gases'. And

Vicq d'Azyr praises MacBride in his *Éloges*, published in 1780.

Once we have fully understood that fermentation is a *primary* phenomenon for a general intuition, we can see why attaching an abundance of adjectives to it is all that is required in order to account for the most diverse of chemical phenomena. Pre-scientific thought is content with this, considering as it does that classifying phenomena means that they are already known. The Abbé Poncelet, for example, also believes that fermentation is essentially a movement and writes that: 'Since there are several degrees of movement, there can be several degrees of fermentation which are usually referred to in terms of their relation to the senses of taste and smell. Thus, we can speak of a fermentation that is sour, bitter, acescent, alkaline, vinous, acetous, aromatic, fetid, styptic, etc'. The Abbé Poncelet is in addition quick to criticise 'the abuse of words (that) has cast strange darkness over ideas that are believed to have an abstract or metaphysical being' (like movement). A rather curious feature of the pre-scientific mind is that it cannot bring its criticism to bear on itself. The scientific mind has a very different ability to engage in self-criticism.

As in the case of coagulation, we can give examples in which too general a concept of fermentation is manifestly over-extended. For Geoffroy, 'Vegetation is a kind of fermentation that unites some of these same principles in Plants, while rejecting the rest'.[11] Here, fermentation is such a general process that it brings opposites together. Writing in 1742, the same year as Geoffroy, an unknown author says that 'In a bunch of grapes, the vinous juices do not ferment in any other way than in the barrel ... We have the same ferments, the same actions, and identical ends; to these you can compare in a general way all that goes on in the history of plants. Thus, fermentation is established on a general system (that) continually varies in its objects'.[12] To this excessive and unproven generalisation can be compared Boerhaave's opinion that when prepared by appropriate fermentation, all plants give forth vinous spirits which are wafted into the air: 'And in this view we now look upon this Air again as a Cloud, as it were, of Spirits of Wine'.[13]

The explanatory value of the idea of fermentation is of course carried over into the mineral kingdom. For Lémery:

> in the production of metal, fermentation, which acts like fire, removes the crude and earthly parts ... A degree of fermentation is needed for the production of metals that is not found in every kind of earth ... Since metal is a work of fermentation, the Sun or the heat of subterranean fires must of necessity co-operate in it ... Fermentation often causes there to rise to the mountain top ... threads of heavy ore or some marcasite.[14]

Here again, as has already been seen with regard to coagulation, explanation by the *general* slides into explanation by the *large* and becomes a cosmogonic principle. Thus, Lémery – who is however a gifted instructor – is carried away as so many are by his learned reverie. What is boiling there in his retort is all he needs in order to form an image of what is going on at the centre of the earth.

The general theme of fermentation can bring together the most heterogeneous of material phenomena: all that is required for this is a set of adjectives. For example, the Comte de Tressan explains electrical phenomena in terms of fermentations. He specifies hot fermentations that produce expansion and cold ones that give a 'coagulum'.[15] With this kind of generalisation encompassing two opposites, he can defy contradiction.

Having now characterised the pre-scientific aspect of the theme of fermentation, it would be very easy to show modern scientific thought to be a differential threshold of culture where this theme is concerned. In particular, it could be shown that no eighteenth-century observation gave rise to a nineteenth-century technique. No comparison is possible between an observation made by MacBride and a technique used by Pasteur. Modern scientific thought strives to specify, to limit, and to purify substances and their phenomena. It looks for the specific and objective ferment, not universal fermentation. In Marcel Boll's excellent phrase, what characterises modern scientists is 'objectivity, not universalism: thought must be objective and will only be universal if it can be so, if reality permits it to be universal'.[16] Objectivity is in fact determined through precision, through the coherence of attributes and not through collecting more or less analogous objects. This is so true that what limits an item of knowledge is often more important for the advancement of thought than what vaguely extends knowledge as a whole. Every scientific concept must, in any case, have its anti-concept linked to it. If *all things ferment*, then fermentation is very close to being a phenomenon lacking in any interest. It is therefore desirable to define what does not ferment and what can put a stop to fermentation. In Pasteur's time in fact, the conditions of sterilisation were integrated into knowledge of the conditions of fermentation and regarded as essential to this. Modern science's tendency to reduce rather than augment observed quantities can be seen even in the simple distinction made between the large and the small. Precision chemistry operates on very small quantities of matter. Relative error would however diminish if larger quantities were taken. Techniques are more reliable though

with sensitive instruments. The ideal that comes before all else here is that of limiting. Knowledge that lacks precision or better, knowledge that is not given with its conditions of precise determination is not scientific knowledge. General knowledge is almost inevitably knowledge that is vague.

NOTES

1 Bachelard's footnote: Justus de Liebig, *Lord Bacon*, trans. (Paris: 1866).

2 Bachelard's footnote: Abbé Bertholon, *De l'Électricité du corps humain dans l'état de santé et de maladie*, 2 vols. (Paris: 1786).

3 Bachelard's footnote: *Histoire de l'Académie des Sciences*, vol. 1, 87. The *Académie des Sciences* was founded in 1666 by Colbert (Louis XIV's powerful finance minister), for the study of problems in mathematics, physics, and chemistry.

4 Bachelard's footnote: Albert Rivaud, *Le Problème du devenir et la notion de la matière dans la philosophie grecque depuis les origines jusqu'à Théophraste* (Paris: 1905), 5.

5 Bachelard's footnote: Wallerius, *De l'Origine du Monde et de la Terre en particulier*, trans. (Warsaw: 1780).

6 'Hast thou not poured me out as milk, and curdled me like cheese?' (*Job*, 10: 10). I am grateful to R. J. Abbott for his help with translating the Latin phrases used in this book.

7 Bachelard's footnote: Crosset de la Heaumerie, *Les Secrets les plus cachés de la philosophie des Anciens, découverts et expliqués, à la suite d'une histoire des plus curieuses* (Paris: 1722).

8 David MacBride, *Experimental Essays on Medical and Philosophical Subjects*, (London: 1764); quotations here are from this text. Bachelard uses the French translation (Paris: 1766).

9 'The fixed air' is the old name for carbon dioxide.

10 Bachelard does not give the source of this quotation. Stephen Hales (1677-1761), an Anglican clergyman and scientist, was known for his investigations of the phenomena of pneumatic chemistry, i.e. the processes of release of aerial fluids and the reverse processes of 'fixing' air in solids or liquids. This quotation is doubtless from his book *Vegetable Staticks* (1727).

11 Bachelard's footnote: *Histoire de l'Académie des Sciences*, 43.

12 Bachelard's footnote: Anonymous, *Nouveau Traité de Physique sur toute la nature ou méditations, et songes sur tous les corps dont la Médecine tire les plus grands avantages pour guérir le corps humain; et où l'on verra plusieurs curiosités qui n'ont point paru*, 2 vols. (Paris: 1742).

13 Herman Boerhaave, *Elements of Chemistry*, translated from the original Latin by Timothy Dallowe (London: 1735); quotations given here are from this text. Bachelard

uses the French translation (Leiden: 1742) of Boerhaave's *Elementiae Chemiae* (Leiden: 1724).

14 Bachelard's footnote: Nicolas Lémery, *Cours de Chymie*, 7th ed. (Paris: 1680).

15 Comte de Tressan, *Essai sur le fluide électrique considéré comme agent universel*, 2 vols. (Paris: 1786); the title is preceded by the author's credentials as 'one of the forty members of the *Académie française*, a member of the Royal Academies of Science in Paris, London, Edinburgh, Berlin, Nancy, Rouen, Caen, Montpellier, etc.' Bachelard omits his source here, but refers to de Tressan's book in a note in Chapter 5.

16 Bachelard does not give the title of Marcel Boll's article, simply referring in the text to the journal concerned, *Mercure de France*, and its date, 1 May 1929.

Chapter Four

An example of a verbal obstacle: sponge. On the over-extension of familiar images

I

Our study of two general themes of pre-scientific knowledge has shown them to exemplify the ease with which the pre-scientific mind gives way to indefinite generalisations. We now wish, in this short chapter, to be even more precise and consider an instance where a *single* image or indeed a single word constitutes the entire explanation. Our intention is to show that these purely verbal habits are obstacles to scientific thought. We shall moreover have an opportunity to develop the same ideas at the end of our chapter on the substantialist obstacle, where we shall be discussing verbal explanation with reference to an adjective-laden substantive that substitutes for a substance with a wealth of powers. Here though we shall be taking the simple word 'sponge' and seeing that it allows the most varied of phenomena to be *expressed*. And because we are expressing these phenomena, we believe we are explaining them. We believe we know them because we recognise them. In phenomena designated by the word 'sponge', the mind is not however taken in by some power of substance. The function of the *sponge* is clearly and distinctly obvious, so much so that we do not feel the need to explain it. In explaining phenomena by the word 'sponge', we do not therefore have the impression that we are lapsing into some obscure substantialism; nor indeed do we have the impression of *theorising* because this function is founded in experience. Sponge is therefore a *denkmittel* of naive empiricism.

II

Let us now see what a major writer has to say. In an article of Réaumur's, published in 1731 in the *Mémoires de l'Académie royale des Sciences*, we

read that:

> It is a fairly common idea to regard the air as being like cotton, like wool, and like sponge, and as far more spongy than all the other bodies or collections of bodies to which it can be compared. This idea explains very well why the air is so greatly compressed by weight and also why it can be extremely rarefied, appearing as a volume far greater than the one we had previously seen.

Equipped with this metaphorical apparatus, Réaumur will make this reply to Mariotte, though Mariotte had however shed some light on the problem by likening the phenomenon of the dissolving of air in water to the dissolving of a salt. Réaumur thinks that:

> Mariotte has taken his supposition further than he needed. It seems to me that instead of supposing that water can dissolve air, which is moreover a fairly difficult kind of dissolving to conceive, we shall have everything necessary for the explanation of the phenomena we are dealing with here if we content ourselves with supposing that water can penetrate air and can dampen it.

If we follow Réaumur's explanation in detail, we shall get a good idea of a *generalised image*, which is expressed by a single word, the leitmotif of a worthless intuition. He writes thus:

> Let us continue to regard the air as resembling spongy bodies in its structure, as one of those bodies that water can penetrate and that can be soaked in it, and we shall cease to be surprised that the air that is contained in water cannot be any more compressed there and that it takes up so little space. If I wrap a sponge in a membrane of some sort that water cannot penetrate and then hold it suspended in the water by means of a thread attached to the bottom of the flask, the sponge will then be as compressible as it was when surrounded by air. If I compress the water using a piston or some other means, the water will go down and the sponge will be forced to occupy a far smaller volume, its parts obliged to go and lodge within the empty spaces they tend to preserve between each other, and the water will then fill the space that the sponge's parts have left. If we cease to compress the water, the sponge will return to its first state ... If we then remove from our sponge the covering in which it had been wrapped, this will allow the water to seep within it. Let us give it the time to fill all the empty spaces

> between the spongy filaments and then if we again use a piston to compress the water, we shall find that, unlike the first time, the sponge either does not yield at all or does so only a very little. The sponge has therefore become incompressible or almost incompressible; the parts that have been compressed can no longer find empty spaces in which to lodge for water has filled them; a part that has found lodging puts a stop to the strivings of another part that would drive it out. If the air can therefore be penetrated by water as a sponge is and if water can fill the empty spaces between its parts, then we see that it ceases to be compressible.

We ought to ask readers to forgive us for quoting this long and ill-written passage from the hand of a famous author. We have though spared them many others of the same style in which Réaumur endlessly explains phenomena in terms of sponginess. We needed however to give a fairly lengthy example where the accumulation of images is obviously to the detriment of reason and where the concrete, heedlessly amassed, becomes an obstacle to an abstract and clear view of the real problems.

Réaumur does subsequently state that what he had proposed was but a sketch and that the 'sponges of the air' can of course be given completely different forms from ordinary sponge. Yet all his thought has developed from this image and cannot leave its primary intuition behind. When he wishes to erase the image, the image's function remains. Thus, Réaumur refrains from deciding on the form of the 'grains of air'. He requires only one thing for his explanation and that is that 'water can penetrate the grains of air'. In other words while he is in the end very willing to sacrifice the sponge, he wishes to keep *spongiosity*. We have proof here of what is simply and solely a linguistic movement which, by associating an abstract word with a concrete one, believes that it has made thought progress. A theory of coherent abstraction needs to be far more detached from initial images.

We shall perhaps gain a better idea though of the inappropriately metaphorical nature of explanation in terms of sponge if we turn to instances in which such an explanation is offered for less immediate phenomena. Thus, Benjamin Franklin writes that:

> Ordinary matter is a kind of sponge for the electric fluid; a sponge would not take in water if the parts of the water were not smaller than the pores of the sponge; it would only take it in very slowly if there was not a mutual attraction between its parts and those of the sponge; the sponge would absorb water more quickly if the mutual attraction between the parts of the water did not oppose it, some force having to be employed in order to

> separate them; lastly, absorption would be very quick if instead of attraction there was between the parts of the water a mutual repulsion that combined with the attraction of the sponge. This is precisely what happens with electric matter and ordinary matter.[1]

All these details and suppositions, these sketches he then seems to regret, show fairly clearly that Franklin is trying to overlay electrical experiments on an initial experience of sponge. Yet Franklin is not just thinking in terms of sponge. For him, sponge is a real *empirical category*. Perhaps this simple object had filled him with wonder when he was young. This happens quite frequently. I have often come upon children gazing in fascination as blotting paper 'drinks up' a blob of ink.

This kind of overlaying will of course be performed more quickly, more directly – if that is possible – and less guardedly by minor writers. For them, this image explains things automatically. In a treatise by Father Béraut, this double explanation is found condensed: all kinds of glass and vitrifiable matter are 'sponges of light because they (are) all penetrated by the matter that makes light; for the same reason, it can be said that they are all sponges of electric matter'.[2] Lémery called Bologna stone a 'sponge of light' a little more accurately for after this phosphorescent stone has been left in the sun, it retains a certain quantity of 'luminous matter' that it then allows to disperse. Equally swiftly, in just a couple of lines, Marat explains the cooling of a hot body plunged into air or water: 'Here, air and water simply act like sponges, for a body cools another that it touches only by absorbing the igneous fluid coming out of it'.[3]

Such a clear image can be more confused and complicated when used. Thus, the Abbé de Mangin states briefly that 'Ice being a sponge of water thickened and frozen when fire is withdrawn, it is disposed to receive with ease every fire that is presented to it'.[4] It seems that we are witnessing in this last instance the interiorisation of sponginess, which here is a disposition to receive and to absorb. Examples could easily be found in which we thus come back without realising it to substantialist intuitions. Sponge has therefore a secret and primordial power. For the Cosmopolite, 'the Earth is a sponge and the receptacle of the other Elements'.[5] An obstetrician called Jean-Pierre David finds the following image a useful one: 'blood is a kind of sponge that is impregnated with fire'.[6]

III

We shall perhaps gain a better idea of the extent to which the image of

a sponge serves as an epistemological obstacle if we look at the difficulties faced by a patient and ingenious experimenter as he tried to rid himself of it.

In 1785, J. H. van Swinden published his *Recueil de Mémoires*, giving it the title *Analogie de l'électricité et du magnétisme*.[7] Here, he presents a large number of objections to the many analogies used by those claiming to bring electricity and magnetism together in one and the same theory. On several occasions, van Swinden states his preference for experiments on which the light of mathematics has already shone. However, those who would be constructors of mathematical thought must first be iconoclasts. This then is van Swinden's programme: 'I shall go on to examine the experiments by which Cigna believed he could show iron to be a conductor of the magnetic fluid, or a *sponge* for it as Brugmans thought'. Brugmans's intuition is given here, in all its naivety: 'Just as a sponge transports water through its whole mass, with more water being transported as the volume of the sponge increases, so iron, which has the greatest mass or volume, seems to *attract* and *extract* (abducere) a greater quantity of Fluid than the Iron of lesser volume'. The function of the iron that has just been magnetised is to 'transport this Fluid to a place where it was not, just as a sponge will, when plunged into water, suck it in and transport it'.

It was only after very many different experiments that van Swinden believed he could rightfully reject this intuition. He therefore writes that:

> This expression 'iron is a sponge for the magnetic Fluid' is therefore a *metaphor* that turns away from the truth, and yet all explanations are based on this expression which is taken in its *literal sense*. In my view though it is not correct to say that all Phenomena can be reduced to this, that Iron is a sponge for the magnetic fluid, and then to argue however that appearances deceive us here. It is not correct to think that reason shows these expressions to be erroneous while nevertheless using them to explain Experiments.

Despite its slightly awkward formulation, van Swinden's thought is very clear: it is not as easy as we make out to confine metaphors to the realm of expression alone. Like it or not, metaphors seduce reason. They are particular and distant images that imperceptibly turn into general schemata. A psychoanalysis of objective knowledge must therefore take great care to remove all the colour from these naive images even if it cannot erase them. Once abstraction has gone through this process, it will be time to *illustrate* rational schemata. To sum up: primary intuitions are an obstacle to scientific thought; only an illustration that works beyond the concept and brings back a little colour to essential features can help scientific thought.

IV

In addition, examples can be found where very great minds are stuck, so to speak, in primary images. For Descartes, doubting the clarity and distinction of the image offered to us by the sponge means making explanations unjustifiably *over subtle*. 'I am indeed unable to say', he writes, 'why this rarefaction of bodies has been explained by some as the result of augmentation of quantity rather than by the example of the sponge'.[8] In other words, the image of the sponge is *sufficient* in a particular explanation and can therefore be used to organise different experiences. Why look for anything more? Why not think in terms of this general theme? Why not generalise what is clear and simple? Let us therefore explain complex phenomena by means of simple ones, in exactly the same way that light is shed on a complex idea by breaking it down into ideas that are simple.

Although the details of this image may come to be obscured, this must not lead us to abandon it. We have a hold on one of its aspects and that is enough. Descartes's confidence in the clarity of the image of the sponge is very symptomatic of this inability to bring doubt to bear on the detail of objective knowledge, to develop a discursive doubt that would wrench asunder all reality's bonds and images' every angle. *General* doubt is easier than *particular* doubt. Descartes goes on:

> For although when air or water are rarefied we do not see any of the pores which are rendered large, nor any new body that is added to occupy them, it is yet less consonant with reason to suppose something that is unintelligible in order to give a merely verbal explanation of how bodies are rarefied, than to conclude in consequence of that rarefaction, that there are pores or interstices which become greater, and which are filled with some new body, although we do not perceive this new body with the senses. For there is no reason which obliges us to believe that we should perceive by our senses all the bodies which exist around us. And we perceive that it is very easy to explain rarefaction in this manner though not in any other.

In other words, a sponge shows us sponginess. It shows us how one particular kind of matter 'is filled' with another. This lesson in *heterogeneous fullness* suffices to explain everything. The metaphysics of space in Descartes is the *metaphysics of the sponge*.

V

The idea of the *pore* could be studied in connection with the intuition of the *sponge*: it is indeed such an enduring leitmotif in pre-scientific explanation that it would take an entire book to trace all its ramifications. With the help of this idea – a particularly specious one – opposites can easily be reconciled. A door has to be either open or closed. But a pore is open to some while being at the same time closed to others. There are specific pores for specific kinds of matter. The image can work in both senses, just like that of the sponge, either absorbing or filtering. It is scarcely surprising then that this image should have been seen as deriving from a fundamental property of matter. As the Comte de La Cépède wrote in 1782, 'All the bodies in nature are filled with pores; porosity is therefore a general property of bodies'.[9]

VI

Many other studies similar to that outlined in this chapter could be made without any difficulty. It would fairly soon be seen that objective knowledge often gathers around privileged objects, around simple instruments that bear the mark of *homo faber*. Here, we could study the lever, the mirror, the sieve, the pump... We would note the existence of different and particular kinds of physics, which are soon generalised. Still in the same spirit, we could study particular phenomena such as *collision*, which is *so unimportant in natural phenomenology* and yet which has such an important role to play in intuitive explanation and in certain philosophical cultures. We could draw up an endless list of over-simple images that are boldly put forward as explanations. Let us give a few examples here. Under the cover of the following quick image, Franklin notes, with reference to electricity, the power of what is pointed: 'just as when pulling out the hairs of a horse's tail a degree of force that is not sufficient to pull out a handful at a time is enough to remove the hairs one by one, so a blunt body that is presented cannot pull out several parts at a time while a pointed body will, without any more force, easily remove them one by one'.

In 1782, Marat *explains* the electrical machine by comparing it to a pump: 'It is rightly compared to a pump: the wheel represents the pistons of the pump, the cushions are the immediate source from which the wheel draws the fluid, and the insulated wire forms the reservoir in which it places the fluid'.[10] There is no mystery and thus no problem. We may well ask how the extension of such an image could serve to improve technique and to *think* the experiment. Ought one to put in bigger cushions so as to have a larger source?

Should one give the wheel a backward and forward motion so as to imitate the pump? Modern science does in fact use the analogy of the pump in order to *illustrate* certain characteristics of electrical generators, but this is to try to clarify the *abstract* ideas of difference in potentials and in the intensity of the current. Here we see a striking contrast between the two ways of thinking. The hydraulic analogy comes in *after* the theory in the scientific way of thinking. In pre-scientific thinking, it comes in *beforehand*. Were the objection again raised here that Marat is a second-rate scientific writer, we would reply that his works were much quoted at the end of the eighteenth century. We would also reverse the objection by repeating that what characterises the pre-scientific period is in fact the great influence exercised by second-rate writers. They were very active workers in the scientific community. This is no longer the case today. Marat performed a prodigious number of experiments, some five thousand on light, he says. And not a single one of these five thousand experiments has been remembered by physics. Any modern student working in a research laboratory under the direction of a distinguished scientist can, on the contrary, have the hope that what they are doing will be useful.

Immediate metaphors constitute a danger for the formation of the scientific mind because they are not always fleeting images; they encourage an autonomous kind of thought and tend to come to completeness in the realm of images and indeed end there. Let us give an example of such an ending. In order to explain thunder, Father de Lozeran du Fesc likens its matter to gunpowder. From a chemical point of view, he claims that in the exhalations perceptible in stormy weather he can find the equivalent of nitre,[11] of carbon, and of sulphur whose mixture, as we know, constitutes gunpowder. From a historical point of view, such a statement can be regarded as quite plausible, especially if we consider the highly valorised ideas that people have held for centuries about exhalations. What we have here is, in short, just one wrong idea among many about the *chemical nature* of thunderbolts. But let us see how this naive image of thunder's explosion ends. In order to explain how thunder-powder ignites, this writer uses a theory of vortices which, it should be said, does not follow Cartesian theory. This is how he concludes:

> Since there is no air along the axis of these whirls (the vortices), and since their sides are extremely resistant, which is proved as much by the fact that they support the whole weight of the atmosphere as by the surprising strength of the cloud columns that uproot the largest trees and topple houses, their form is like a long Gun. When therefore Thunder's matter comes to explode, it must mostly flow the length of this Gun with the utmost speed.[12]

Thus, gunpowder did not suffice and there had to be a gun for the theory to be complete. Father de Lozeran du Fesc's treatise was awarded the *Académie*'s prize in 1726; the *Académie* had not been able to award its prize the previous year and was very pleased to have waited for such a fine piece of work.

However, all these rather puerile images which are, as it were, apprehended in their external features, are far from being the most active ones. In the context of our discussion, the most powerful obstacles correspond to the intuitions of realist philosophy. What these highly materialised obstacles bring into play is not general properties but substantive qualities. And it is here, in this more secret, more subjective, and more inward experience, that real mental inertia lies. It is here that we shall find words that really are obstacles. We shall therefore leave our examination of a number of substances to which undue preference is given until the end of our chapter on the *substantialist obstacle*: substances of this kind will enable us to gain a better understanding of the ideas of epistemological preference and epistemological valorisation. And at the end of that chapter we shall also be fully developing the psychoanalysis of objective knowledge.

NOTES

Bachelard's footnote: Benjamin Franklin, *Expériences et observations sur l'électricité*, trans. (Paris: 1752); my translation, a copy of Franklin's *Experiments and Observations on Electricity* not having been located.

2 Bachelard does not give the source of this quotation.

3 Bachelard's footnote: Marat, Doctor of Medicine and Physician to the Bodyguard of the Comte d'Artois, *Découvertes sur le Feu, l'Électricité et la Lumière, constatées par une suite d'expériences nouvelles* (Paris: 1779).

4 Bachelard's footnote: Abbé de Mangin, *Question nouvelle et intéressante sur l'électricité* (Paris: 1749).

5 Bachelard's footnote: *Cosmopolite ou nouvelle lumière chymique. Pour servir d'éclaircissement aux 3 Principes de la Nature* (Paris: 1723). In his text, Bachelard refers to this work and to its author as 'the Cosmopolite'; this was the pseudonym adopted by the Scottish alchemist Alexander Seton. Little is known of Seton apart from his travels in Europe, visiting other alchemists, between 1602 and his death on either 31 December 1603 or 1 January 1604. He was regarded as possessing the 'arch-secrets' of alchemy, and this work is a major alchemical text, to which Bachelard refers several times. Its importance is underlined by the story of skulduggery attached to it: this text was first published in Cracow in 1604 as *Novum Lumen Chymicum* by

the Moravian Michael Sendivogius, who adopted Seton's pseudonym and claimed to be the author; he had rescued Seton from imprisonment in Dresden by the Elector of Saxony, in return for an ounce of his transmutative powder; Sendivogius was quick to marry Seton's widow – in the vain hope that she knew his secrets – who gave him Seton's text. There were many French and English editions of this text in the seventeenth and eighteenth centuries.

6 Bachelard's footnote: Jean-Pierre David, Doctor and Physician, Master of Arts and Surgery of the University of Paris, Royal Professor of Surgery and Anatomy in Rouen, Lithotomist in Residence and Surgeon in Chief at the Hôtel-Dieu hospital, and Member of the Rouen Academy of Science, Literature, and the Arts, *Traité de la nutrition et de l'accroissement, précédé d'une dissertation sur l'usage des eaux d'Amnios* (Paris: 1771).

7 Bachelard's footnote: J. H. van Swinden, *Analogie de l'électricité et du magnétisme*, 3 vols. (The Hague: 1785).

8 Bachelard refers here to René Descartes, *Principles of Philosophy*, Part 2, section 7; the translation used is by Elizabeth S. Haldane and G. R. T. Ross, *The Philosophical Works of Descartes*, 2 vols. (Cambridge: 1911; London: 1968), vol. 1, 257.

9 Bachelard's footnote: Comte de La Cépède, Member of the Academies and Royal Societies of Dijon, Toulouse, Rome, Stockholm, Hesse-Hombourg, and Munich, *Physique générale et particulière*, 2 vols. (Paris: 1782).

10 Bachelard's footnote: Marat, *Recherches physiques sur l'électricité* (Paris: 1782).

11 'Nitre' is the old word for saltpetre, i.e. potassium nitrate, the main constituent of gunpowder.

12 Bachelard's footnote: Rev. Father de Lozeran du Fesc, of the Company of Jesus, Royal Professor of Mathematics at the University of Perpignan, *Dissertation sur la cause et la nature du tonnerre et des éclairs* (Paris: 1727).

Chapter Five

Unitary and pragmatic knowledge as an obstacle to scientific knowledge

I

We have now examined the generalising function and its dangers with reference to experiences or intuitions that are as well-defined as possible, such as coagulation, fermentation, and the wholly mechanical function of sponge. Yet we can also see the seductive power exercised by far greater generalities. Empirical thought is no longer what is involved here: what we are dealing with is in fact philosophical thought. Here, sweet lethargy halts experience; all questions are stilled in a vast *Weltanschauung*; all difficulties are resolved through a general view of the world, simply by referring to a general principle of nature. Thus, in the eighteenth century the idea of a homogeneous, harmonic, and tutelary nature erases all the singularities, contradictions, and hostilities of experience. We shall show that this kind of generality – and associated generalities – are in fact obstacles to scientific thought. Only a few pages will be devoted to this since it is easily proved. And so as to avoid writing too long a book, we shall not, in particular, make any mention here of literary figures and philosophers. Bernardin de Saint-Pierre's work[1] for instance could, if looked at in some detail, be shown to be a lengthy parody of scientific thought. Much too could be said in criticism of the physics of the kind on which Schelling's philosophy is based. However, writers like these, concerned as they are with something other than scientific thought, have little influence on the development of objective knowledge.

The *literary* aspect of pre-scientific books is though an important sign, and often in fact a bad sign. Whenever a harmony is described in broad outline there is also a grandiloquence we need to characterise, a grandiloquence that ought to catch the psychoanalyst's attention. It is indeed the undeniable mark of excessive *valorisation*. We shall only be giving a few examples of this, however, because the pages where this grandiloquence is seen are among

the most boring and useless written by 'physicists'.

In a book written as if a series of *informal letters*, an unknown author begins his *Planétaire ou abrégé de l'histoire du Ciel* in these terms: 'Do I take too bold a flight when daring to rise to the heavenly heights? And shall I be accused of temerity in wishing to examine those torches that seem attached to the vault of the firmament?' In his twenty-ninth letter, the same author approaches the study of light in this way:

> What sublimity there is in the words used by Moses to convey God's will to us: *Fiat lux, et facta est*, with no interval between thought and action ... This Expression is so marvellous and so divine that is uplifts the soul, just as it fills it with respect and admiration ... It is this precious fluid, this luminous Star, this element that illuminates the universe, this light in fact, that we must study, seeking its causes and showing its effects.

There is the same religious wonderment in the 105 page discourse that serves as an introduction to the Comte de La Cépède's *Physique générale et particulière*. Here, he writes for example that 'We have considered light, that being which each day seems to produce the universe anew before our eyes, and draws again for us the image of creation'. The lack of objectivity in this wonderment is also clear to us. Indeed, were we to put aside the unconscious *values* that come each morning and comfort the hearts of all who lie engulfed in night, then this 'image of creation' offered by a radiant dawn would seem very feeble and unimpressive. After an attempt at analysis, the Comte de La Cépède promises us a stirring synthesis:

> We have sufficiently examined, taking each separately, the different parts forming the skeleton of nature; let us bring these parts together, let us clothe them in their rich finery, and let us make of them that great body, full of life and perfect, that constitutes in fact nature in all its power. What a magnificent spectacle is spread before our eyes! We see the universe unfold and extend; a numberless host of bright orbs, themselves the sole source of their own brightness, shines there in splendour.

A truly literary pen may well be inspired by similar wonderment but it will then confide in us more discreetly and also more inwardly: it is not so much the *admirable spectacle* but rather the *admirer* that we ourselves admire and love. At the outset of a psychological study, before the novel begins and the heart confides, a landscape may well prepare an inner state of mind and spirit, serving to establish a symbolic link between the work and the

reader. At the outset of a work on physics, such expressions of wonderment, were they effective, could only make for harmful valorisations. All this literary ostentation can only end in disillusionment.

All authors are no doubt inspired by the desire to valorise their chosen subject. They wish to show, right from their preface, that they do *have a subject*. Yet ways of giving value today are, however reprehensible, more discreet; they are closely connected to the work's content. We would no longer dare to say, as de La Chambre did, that the subject discussed in his book *La Lumière* will find its application in the light of the spirit, which is that of honour, merit, and virtue.[2] We would turn aside arguments such as these, found in his preface: 'Light fills and gladdens all Nature. Where it is not, there is no joy, no strength, and no life, but only horror, weakness, and nothingness. Of all perceptible creatures, light is therefore the only one that most resembles and most corresponds to the Divinity'.

This need to *elevate* subjects is consonant with an ideal of *perfection* given to phenomena. Our remarks are therefore less superficial than they seem, for perfection will serve as evidence and as proof in the study of physical phenomena. For example, in order to find the essence of light, de La Chambre raises the following question: 'Let us therefore see whether we can find something that dazzles the mind as much as the eyes'. It is thus a matter of placing light on a *scale of perfection* that goes from matter to God, from the work to the worker. It is very noticeable at times that *value* is disturbing the table of presence: thus, this writer refuses to establish any link between rotten wood that shines (due to phosphorescence) and 'substances as pure and noble as the Stars are'. On the other hand, de La Chambre speaks of 'angels ... whose extension is so closely related to that of Light'. The idea of perfection will often be powerful enough to contradict familiar intuitions and to form an obstacle to useful research. Thus, he writes that:

> Were we to follow the common view, we would need to add at this point that of itself, Light grows weaker as it goes farther from the luminous body; that following the example of all other qualities, it gradually loses its virtue as it makes progress; and that this is the true reason why it grows weaker and even in the end becomes imperceptible. Yet whatever may be the case with regard to the other qualities, we hold it to be certain that Light is of a nature and of an order so high above them that is not subject to any of their infirmities ... (its) weakening is only external, and it does not affect the essence and inner virtue of Light.

The sterilising influence of an irregular valorisation can be very clearly

seen here. A physical fact as plain as the decrease in illumination that is in inverse ratio to the square of distances from the source of light is obscured here for reasons that have nothing to do with objective thought. We can also see that for the pre-scientific mind the *perfection* of physical phenomena is a fundamental principle of explanation. The principle of this perfection is, of course, often attached to the creative act. 'We can conclude', writes de La Chambre, 'that this first and all-powerful Word which created (light) when the world was born still has the same effect at every moment, drawing from nothingness this wondrous Form and introducing it into bodies disposed to receive it'.

Certain theories are entirely bound up with a path towards perfection. Thus, Hélène Metzger has shown with great clarity that alchemy is only conceivable if substances develop in one direction only, in that of a completion, a purification, and a conquest of *value*.[3]

In all these works, the idea of perfection is not therefore a value that comes along and is added as an afterthought, like some lofty philosophical reflection, to conclusions drawn from experience: it is fundamental to empirical thought, which it directs and epitomises.

II

For the pre-scientific mind, unity is a principle that is always desired and always cheap to achieve. Only one capital letter is needed for this to happen. The different natural activities thus become the varied manifestations of one and the same Nature. Experience cannot be conceived as self-contradictory or as compartmentalised. What is true of something large must be true of something small and vice versa. Error is suspected whenever there is the slightest duality. This need for unity poses a multitude of false problems. De Marivetz and Goussier for example are worried about an entirely mechanical duality that might be suspected at the root of their cosmogony. Since they conceive the first movement of the universe as coming from God, they find themselves faced with a problem. Could it not be that the first impulse comes like a kind of dynamic creation and is added to material creation, so that what we have is creation in two phases, things first and then movement, a duality that is doubtless outrageous in their eyes. They then take the trouble to answer that:

> they did not in any way suppose that this Artisan had been obliged to strike this motive force, that is to say the Sun, both physically and mechanically by imparting movement to it, either at the centre of the mass or at any other point in it, or at the centre and at the same time at any other point. They have written: *God said unto these bodies that they should turn about their centres*. Now, there is nothing here that cannot be conceived. From this order, whose execution becomes Nature's sole law, they deduce all the phenomena of celestial movements.

Unity has been speedily achieved and duality quickly and deftly removed! What could not be conceived of mechanically, through a physical action, thus becomes conceivable when linked to a divine action. Who cannot see that *conceivability* has changed ground? A modern mind has broken with this myth of *the unity of the conceivable*. And in particular, theological problems are thought by the modern mind in different terms from cosmological ones.

Moreover, a whole book could be devoted to a study of works – still numerous in the eighteenth century – in which physics is associated with theology, *Genesis* is regarded as a scientific cosmogony, and the history of the heavens is considered 'according to the ideas of Poets, Philosophers, and Moses'. In the eighteenth century, everyone had a copy of books like that by the Abbé Pluche, whose work was inspired by these ideas.[4] These works continued to be reprinted up to the end of the century.

Without expatiating on the folly of such ideas, let us very briefly attempt to describe their authors' inner state of mind and spirit. No sooner have they put forward one of these hypotheses of grandiose unification than they give proof of their intellectual humility and remember that God's purposes are hidden. Yet this humility, which is so eloquently and so belatedly expressed, ill disguises their initial immodesty. Pride is always found at the root of knowledge that declares itself to be general as it goes beyond experience, as it leaves the domain of experiences in which it might encounter contradiction.

III

Let us return though to principles of harmony that are apparently closer to the objective world. Historians of chemistry have made lengthy studies of the medieval and Renaissance theories that were based on sweeping analogies. Hélène Metzger in particular has brought together in well-documented books everything to do with Paracelsian analogies. She has shown that an analogy was established between stars and metals, between metals and parts of the body. Hence, there was a kind of universal triangle uniting heaven, earth, and humankind. Upon this triangle there played ultra-Baudelairian 'cor-

respondences'[5] in which pre-scientific reveries were endlessly transposed. So convincing was this trilogy that even the treatment of disease was entrusted to it. As Metzger says, 'the appropriate remedy for any human disease, for any accidental disharmony in an organ, is the metal that corresponds to the planet analogous to the diseased organ' (*Les Doctrines chimiques en France*, 104). Need we add that these *analogies* do not encourage any research to be made? On the contrary, they *put thought to flight*; they preclude that *homogeneous curiosity* which gives us the patience to follow a well-defined order of facts. Proofs are always *transposed* here. You thought you were doing chemistry in a laboratory flask, but it is the liver that answers you. You thought you were examining a patient by auscultation, but what influences the diagnosis is the conjunction of a star.

It is easy to find examples where belief in this harmonic unity of the world leads to an *over-determination* being posited that is highly characteristic of the pre-scientific way of thinking. Astrology is a particular instance of this over-determination. In *L'Harmonie céleste* in 1672, Fayol writes:

> Without derogation from holy Providence, it is said that changes in Kingdoms and in Religions come but from the Planets' changes from place to place, and that their eccentricity is the wheel of fortune which establishes, augments, or diminishes States according to where it begins or ends in the world... So that by calculating the movement of the small circle that carries the centre of the eccentric orbit around the circumference, we could know the precise moment when present Monarchies will fall to ruin.[6]

The over-determination of astrology is such that some writers go as far as to use a real logical converse, making inferences about celestial bodies on the basis of their knowledge of human beings. This is not a matter of *signs*, as is too often thought when astrology is discussed nowadays, but of *real and material action*. Claude Comiers recalls that Bodin claims in the second book of his *Théâtre de la Nature* that 'Comets are the souls of Great and Holy persons, who leave the Earth, and rise in triumph to the Firmament; from which it follows that the Peoples abandoned by these fair souls who would in the past quell God's anger, now suffer famine and are afflicted by contagious diseases and the misery of civil wars'.

Thousands of examples could be given where an incredible degree of over-determination directs thought. This is such a clear tendency that it could be said that all non-scientific thought is over-determined thought. Let us give just one example, taken from Fayol's *L'Harmonie céleste*. According to Fayol:

> The cat is influenced by Saturn and by the Moon; so great is its fondness for the herb valerian that when this is gathered at a time when these two Stars are in conjunction, it brings all cats together at the place where it grows. Some argue that this animal is poisonous, its poison being in its fur and in its head: but I believe it to lie only in the head because its animal spirits, which grow when the Moon is full and decline when it is new, are harmful only at full Moon, when they come out of the cat's eyes to communicate their poison. Three drops of blood from a male cat, taken from a small vein under the tail, are effective against the falling sickness; its flesh opens haemorrhoids and purges melancholy blood; its liver is useful in cases of quartan fever and of gout, when cooked and drunk in wine before suffering an attack; fat from a castrated cat softens, warms, and dissipates the humours of gout; its skin is very good on the stomach, articulations, and joints, and warms the parts weakened by cold humours; its excrement makes the hair grow. Whoever wears the herb valerian may carry away any cat they wish without apprehension. This animal heals its eyes by using valerian.

Our sole aim in giving this long and absurd passage is to show how casually the most heterogeneous of properties are juxtaposed, the one determining the other. Everything is then the cause of everything. We shall doubtless be accused of facile point scoring by showing off such foolish nonsense. Indeed, whenever we have quoted pages like this to medical doctors or to historians of science, the rather bad-tempered reply has been that such pages in no way sully purely clinical theories and that such and such a great doctor from the past was obviously free of prejudices of this kind. Our response though was to ask whether medicine was practised by 'great doctors'. And if we wish to assess the difficulties of the *formation* of the scientific mind, ought we not to examine disturbed minds first of all by trying to draw in the boundaries of truth and error? Now, it seems to us a very characteristic feature of the pre-scientific period that over-determination comes and obscures determination. Vagueness then makes a bigger impression than does precision, which defers to it.

We go further moreover, believing that over-determination taught a kind of determination that was simply and solely affirmed without any reference being made to experience. Thus, does the quantitative determination so important in some philosophies – in that of Leibniz for instance – have a more firm foundation than the qualitative determination whose vague pronouncements we have just seen? It is often said that in lifting a finger, we disturb the earth's centre of gravity and that this very small action determines

a reaction in the antipodes. As though when the earth is properly considered as the group of vibrating atoms that constitute it, its centre of gravity were something other than a statistical point! The philosophical mind is thus in the grip of the absolute of quantity just as the pre-scientific mind is in that of the absolute of quality. In fact, contemporary science learns from *isolated systems*, from fragmented *units*. It is able to maintain isolated systems. And where epistemological principles are concerned, contemporary science maintains that quantities which are *negligible must be neglected*. It is not enough to say they *can* be neglected. This therefore cuts short any purely plausible and unproven determinations. Finally, quantum science familiarises us with the idea of a *quantitative threshold*. There are energies that are insufficient to cross a threshold. Such energies cannot disturb phenomena that are well-defined and properly isolated. It can therefore be seen that the theory of determination must be revised and that the quantitative solidarity of the universe is not a characteristic to be asserted without due caution.

IV

One of the epistemological obstacles related to the unity and power ascribed to nature is the *coefficient of reality* that the pre-scientific mind attributes to all that is *natural*. There is a valorisation here that goes undiscussed, that is endlessly invoked in everyday life, and that is ultimately a cause of confusion for experience and for scientific thought.

Thus, Réaumur attributes to *natural* liquids a particular aptitude for resisting cold:

> We are not surprised that inflammable liquors such as spirit of Wine preserve their liquidity in excessive cold, and we should not perhaps also be surprised that this is the case with powerful acid spirits, and with waters themselves that carry many salts,. But Nature can compose liquors that are not in any way inflammable, that have no acidity we can discern, and that are however able to resist very great cold. I wish to speak of the kind of blood circulating in insects of so many species; going by its colour and taste, our crude senses would swear it to be water, or at least an extremely aqueous liquor.[7]

Certain caterpillars have however resisted the greatest cold, remaining soft and flexible at minus 17° on the Réaumur scale. 'However aqueous they seem', he writes, 'the blood and the principle liquors which are found in the bodies of these insects are therefore of a nature that can withstand excessive

cold without freezing'. We have a fairly clear sense that Réaumur is prejudging experience and that his animist intuition ill prepares him for studying in vitro, as he should do, the phenomena associated with the freezing of saline solutions.

V

Usefulness itself gives a very special kind of induction that might be termed utilitarian induction. It leads to exaggerated generalisations. Our starting-point may then be an established fact, which we may even successfully extend. Yet almost inevitably the pressure exerted by usefulness make us go too far. All pragmatism is bound to be overstated, simply because it is mutilated thought. Humans are incapable of limiting usefulness which, because of its valorisation, is immoderately accrued. The following example shows the unfortunate consequences of utilitarian induction.

For Réaumur, caterpillar pupae 'perspire'. And it is this communication with the outside world that maintains the pupa's hidden life and makes it develop. You only need to cover a pupa with varnish for its development to be slowed down or stopped. It so happens that, making a bold induction, Réaumur thinks eggs are 'kinds of pupae'. He therefore proposes that eggs to be preserved should be coated with tallow or varnish. Nowadays, every housewife uses this excellent method, based as it is on a dubious generalisation. But will utilitarian induction stop here? Will it be content with this first success? The historian of the *Académie des Sciences* dares to go further. The conclusion can perhaps be drawn that 'human beings could also preserve themselves for longer by coating themselves with varnish of kinds suitable to them, as Athletes formerly did and as savages do today, though perhaps with other intentions'.[8] This is not an isolated idea. Bacon already regarded the reduction of perspiration as a way of prolonging life. In 1776, Dr Berthollet does not hesitate to write as follows in his *Observations sur l'air*: 'I believe that were we to suppress perspiration during the first period of life (in young children), urine's passage-ways would enlarge and in them the humours would for ever establish a more abundant flow'.

In all these phenomena, what is sought is purely human usefulness, not just for the positive advantages it may bring but as an explanatory principle. Finding a use means finding a reason. In order to convince people of the magnet's curative action, van Swinden – who is nevertheless very prudently attached to experience – writes: 'Again, I ask all sincere Physicians whether they are within themselves convinced that this magnetic Force, which is so universal, so varied, so amazing, and so admirable, has been produced by the

Creator solely to direct magnetic Needles, which have however been so long unknown to Humankind'.

Phenomena that are the most hostile to human beings are often the subject of a valorisation whose antithetical character ought to attract the psychoanalyst's attention. Thus, for the Abbé Bertholon, thunder brings 'at one and the same time, fear to the most intrepid souls and fertility to the poorest of soils'.[9] It is thunder too that brings 'that productive fire which is rightly regarded as a fifth element'. He goes on: 'The same is true of hail, which also makes the soil very fertile; it has generally been observed that everything turns green again after hail has fallen and that corn especially, when sown after hail, gives an infinitely more abundant harvest than in the years when there has been no hail'. Even earthquakes are propitious for the harvest.

There is an attempt to attribute a characteristic kind of usefulness to a phenomenon's every detail. If usefulness does not characterise a particular feature, then this feature does not seem to have been explained. For pragmatic rationalism, a characteristic that is not useful is an irrational. Thus, Voltaire very clearly sees the usefulness of the earth's annual and diurnal movement.[10] There is only the period of '25,920' years corresponding to the phenomenon of the precession of the equinoxes for which he 'cannot find any perceptible use'. He does his utmost to make this *uselessness* admissible, proving that for the contemporary mind justification by usefulness was the most natural of justifications. We feel that for Voltaire, despite his slight scepticism, heaven is useful to the earth:

> Far from comets being dangerous ... they are, according to (Newton), new gifts from the Creator ... (Newton) conjectures that the vapours which come from them are drawn into the planets' orbits and serve to renew the ever diminishing humidity of these terrestrial globes. Again, he thinks that the most elastic and most subtle part of the air we breathe comes from the comets ... It seems to me that this is a wise man's guess and that if it is in error, then it is the error of a great man.

Flourens has pointed out this systematic reference to usefulness in Buffon's work.[11] He tells us that '(Buffon) now wishes to judge objects only in terms of the relations of *usefulness* or *familiarity* that they have with us; his main reason for this is that it is easier, more pleasant and more useful for us to consider things in relation to ourselves than from any other point of view'. We can see all too well that an empirical examination which, in accordance with Buffon's advice, has its starting-point in the useful and the familiar runs the risk of being obscured by an *interest* that is not specifically

intellectual. A psychoanalysis of objective knowledge must break with pragmatic considerations.

Entire systems have been based on utilitarian considerations. Only usefulness is clear. Only usefulness can explain. Robinet's works are very typical in this regard. He declares for instance that:

> I do not fear to argue here that were there a single instance of real uselessness in Nature, it would be more probable that chance had presided at its formation than that it had an intelligence as its author. It is indeed more uncommon for an infinite intelligence to act without purpose than it would be surprising that by sheer accident, a blind principle is in conformity with order.[12]

Thus, truth must be coupled with usefulness. Truth that has no function is a mutilated truth. And when usefulness has been discerned, the real function of truth has been found. However, these utilitarian views are aberrations. The dangers of finalist explanations have so often been shown that there is no need to place any further emphasis here on this obstacle to a truly objective culture. We simply thought it necessary to point out that this obstacle was particularly dangerous in the eighteenth century. This was because the literary and philosophical exploitation of science was still very easy at this time, and the excesses of Bernardin de Saint-Pierre are simply an exaggeration of a tendency whose vigour we have seen in the work of minor scientific writers.

VI

The need to generalise to extremes, sometimes from a single concept, leads to synthetic ideas that are not about to lose all their seductive power. Nonetheless, these days a certain prudence holds the scientific mind in check. Philosophers are now really the only ones to go in search, if not of the philosopher's stone, then at least of the philosopher's idea that would explain the world. For the pre-scientific mind, the attraction exercised by the unity of explanation by a single characteristic was all-powerful. Let us give some examples. In 1786, the Comte de Tressan's book was published, though it was in fact written in 1747. It asserts that all the phenomena in the universe can be explained by the action of the electric fluid. In particular, the law of gravity is for de Tressan a law of electric equilibrium. Or better, all equilibrium is in essence electric. His two weighty volumes endlessly refer to the essential property of the electric fluid, which is 'to tend at all times to equi-

librium with itself'. Hence, where there is equilibrium, there is an electric presence. This is the sole and disconcertingly inane theorem from which the most unlikely conclusions will be drawn. Since the earth moves round the sun without going any closer to it, this means that there is equilibrium between the electricity of these two stars. To be more precise, plants are said to show the equilibrium between the electricity radiating from the ground and that coming from the sun's rays. De Tressan affirms that 'All possible bodies that touch the earth or are planted in it are so many conductors, receiving and transmitting terrestrial Electricity in proportion to the surging power it then may have, according to the obliquity or verticality of the sun's rays'.

Another writer, the Chevalier de La Perrière, devotes a 604-page book to a synthesis which is every bit as broad and inclusive. He writes in his preface that:

> Electricity's empire is so extensive that it has no boundaries and no limits other than those of the Universe it embraces; the Planets' suspension and course; the eruptions of celestial, terrestrial, and military thunderbolts; meteors; natural and artificial Phosphors; bodily sensations; the rising of liquors in capillary channels; refractions and natural antipathies, sympathies, tastes, and distastes; the musical cure of tarantula bites and of melancholy diseases, vampirism, or sucking exercised in turn on one another by people who sleep together; all these come within its province and are subordinate to it, as is justified by the electrical mechanisms we give of them.[13]

It hardly needs saying that these books by the Chevalier de La Perrière and the Comte de Tressan do not keep their promises. Very many examples could be found in the eighteenth century of books which promise a system but only give an *accumulation* of facts that are ill-connected and therefore ill-understood. They are works that are as useless philosophically as they are scientifically. They do not get to grips with a great metaphysical intuition as the works of Schelling or Schopenhauer do. Nor do they gather together empirical documents as happens in the works of chemists and botanists in the same period of time. In the end, they encumber scientific culture. The nineteenth century, on the other hand, witnessed the almost complete disappearance of these informal and pretentious *letters* written by impromptu experts. This brings about a vastly improved understanding of what scientific culture really is. Elementary books are no longer erroneous ones. This ordering must not lead us to forget the confusion that reigned throughout the pre-scientific era. It is when we become aware of this revolution in the scientific

community that we can really understand the *psychologically formative* power of scientific thought and also come to appreciate the distance there is between the passive empiricism that just records and the empiricism that is active and thought.

NOTES

1 Jacques-Henri Bernardin de Saint-Pierre (1737-1814) is particularly known for his novel *Paul et Virginie*. Bachelard is critical of his scientific pretensions, especially in Chapter 11 when he quotes from Bernardin de Saint-Pierre's *Études de la Nature* (1791).

2 Bachelard's footnote: De La Chambre, Consultant to the King and his first ordinary physician, *La Lumière* (Paris: 1662).

3 Bachelard's footnote: Hélène Metzger, *Les Concepts scientifiques* (Paris: Alcan, 1926), 97, 118.

4 While Bachelard does not specify this book here, he does give details in a footnote in Chapter 11: Abbé Pluche, *Histoire du Ciel*, new edition (Paris: 1788).

5 Bachelard's use of 'correspondences' is a reference to Baudelaire's sonnet 'Correspondances' in *Les Fleurs du Mal* (1857). This poem draws on esoteric tradition, in particular on Swedenborg (1688-1772); according to this theory of 'correspondences', everything on earth symbolises some spiritual reality, all things 'corresponding', that is to say being related, in that they represent the spiritual essence of the universe.

6 Bachelard's footnote: Jean-Baptiste Fayol, commendatory prior of Notre-Dame de Donges, *L'Harmonie céleste* (Paris: 1672).

7 Bachelard's footnote: *Mémoires de l'Académie des Sciences* (1734).

8 Bachelard's footnote: *Mémoires de l'Académie des Sciences* (1736).

9 Bachelard's footnote: Abbé Bertholon, *De l'Électricité des végétaux* (Paris: 1783).

10 Bachelard's footnote: Voltaire, *Physique*; Bachelard refers to vol. 41 in the 1828 edition of Voltaire's *Oeuvres complètes*.

11 Bachelard's footnote: Flourens, *Histoire des travaux et des idées de Buffon* (Paris: 1844).

12 Bachelard's footnote: J.-B. Robinet, *De la Nature*, 3rd ed., 4 vols. (Amsterdam: 1766).

13 Bachelard's footnote: J.-C.-F. de La Perrière, Chevalier, Seigneur de Roiffé, *Mécanismes de l'électricité et le l'Univers*, 2 vols. (Paris: 1765).

Chapter Six

The substantialist obstacle

I

Like all epistemological obstacles, the substantialist obstacle is polymorphic. It is formed when the most dispersed and even the most opposite of intuitions are brought together. The pre-scientific mind has an almost natural tendency to combine in one object all the different kinds of knowledge in which that object has a role to play, without paying any attention to the hierarchy of these empirical roles. It immediately links diverse qualities to substance, whether those qualities are superficial or fundamental, evident or hidden. We could however make a distinction between different sorts of substantialism, the substantialism of what lies hidden, of what is deep and inward, and of obvious quality. Yet once again, such distinctions would lead us to forget the vague and infinitely tolerant character of substantialisation. They would lead us to neglect the epistemological movement that goes alternately between the interior and the exterior of substances, taking advantage of obvious exterior experience but fleeing from criticism in the depths of interiority.

As far as explanation in terms of hidden qualities is concerned, the commonly held view is that we have known how pretentiously erudite and also how misleading this is since Molière showed it to be so. Yet it is a kind of explanation which, while more or less concealed beneath the artifices of language, still threatens culture. It seems that one Greek word would suffice for the sleep-inducing virtue of opium to cease to be a pleonasm when used as an explanation of why opium makes us sleep.[1] Bringing together two etymologies of different characters produces a psychic movement that may pass for the acquisition of knowledge. Whenever a known phenomenon is designated by a learned name, lazy thinking gets a real sense of satisfaction. Certain medical diagnoses and psychological insights that make play with synonyms could easily provide us with examples of these verbal satisfactions. Insights that are either uncoordinated or simply dependent on nuances of language cannot claim to establish a psychological structure. A fortiori, when these insights concern experience and touch on empirical detail, the connection they have with a substance – or with a substantive – cannot establish scientific thought.

II

What is hidden is shut away. By analysing references to what is hidden, it is possible to characterise what we shall call the *myth of interiority*, and then the *deeper myth of inwardness*.

It would of course be easy to show that literary psychology rests on these myths: it is enough to speak slowly and in a *low voice* about a *deep* feeling in order to be regarded as a deep psychologist of the inner life. We may well wonder whether the traditional psychology of feelings would be possible if it were forbidden to use the word 'deep' which it attaches to everything but which only corresponds, in the end, to a mere image. The impression of *depth* remains in fact a *superficial* one: so true is this that it is an impression which is attached to naive feelings especially, to feelings insufficiently worked on and left to nature's monotonous impulses.

Our present task is not however to study the psychology of the self but rather to follow thought as it wanders in search of an object: we need to follow reverie as it *attributes inwardness to objects*. Although the aims are different, the processes are homologous because psychologists of inwardness and naive realists are beguiled by the same seductive charm. This homology is so clear that characteristics could be *exchanged*: realism refers essentially to inwardness just as the psychology of inwardness refers to reality.

All we need do in order to justify this statement is call to mind a variety of intuitions to which value is given: all wrappings seem less precious and less substantial than the material they wrap. For example, while bark is functionally so essential, it is valued simply as protection for the wood. These wrappings are regarded as necessary even in inanimate nature. Paracelsus said that in all things there could be no central part – no core – which did not have scales and no scale which did not have bark. The idea behind substantialism is often illustrated simply in terms of *containing*. Something has to *enclose* and the quality that lies deep has to be *enclosed*. Thus Nicolas de Locques, 'His Majesty's spargyric physician', affirms in 1665 the need for coldness to combat the violence of heat, stating that 'this volatile Coldness casts itself on the surface to prevent the dissipation of heat and serve as

a vessel for it'.[2] Thus, the quality *heat* is kept safely within substance by being wrapped by cold, kept safely therefore by its opposite. This intuitive valorisation of what lies within can lead to curious statements being made. Writing in the *Encyclopédie* about pebbles, Zimmermann says that 'pebbles are always harder and more transparent towards the middle or centre', towards what he calls the inner grain, than in what enwraps them. When intuitions like these are analysed, we soon realise that for the pre-scientific mind *substance has an inside*, or better, that substance *is* an inside.

For this reason, the alchemists' way of thinking was often governed by the task of *opening* substances, in a far less metaphorical way than when psychologists – our modern alchemists – say they are *opening* their hearts to us. Jean Le Pelletier writes that mercuries of metals are too tightly closed, and that sulphurs are 'shut too tight to be opened and developed by the Archeus of our stomach'.[3] A 'key' is always being sought that will open substances. Modern readers have too much of a tendency to take the word 'key' in a figurative sense as simply a way of understanding an arcane text. In many authors, in fact, the *key* is some kind of matter that will open a substance. Even the psychoanalytical meaning of the key appears to be intuitively active here. Thus, one writer suggests striking a substance with a fiery rod in order to open it.[4]

The idea of *turning substances inside out* is symptomatic too. Joachim Poleman wonders whether 'it is only oil that has the power to dissolve sulphur gently and naturally, and to turn it inside out'.[5] Poleman also states that 'the twofold corrosive has completely inverted copper and turned it inside out, and has made it fit not just to yield up its soul but also ... by the virtues of this corrosive, copper's gentle soul has come to gleam, as if through a medium that resuscitates and vivifies'. This surely makes it clear that copper's soul, that copper's precious substance lies within it. The means must therefore be found 'to remove gradually and as though imperceptibly this corrosive of copper, so that (copper) can remain in its inversion and its gentleness, as well as in its luminous and gleaming character'. Thus, the phrase 'someone can be turned inside out like a glove'[6] is a psychological notation which is deeply rooted in the unconscious and which, as we have seen, has given rise to a false conception of substance. There is every indication that it was not the *glove* that taught us this in the first place. The image's conscious clarity conceals, as it so often does, the principle of unconscious conviction.

This strange image of *turning substances inside out* is accepted by minds much closer to scientific thought, for whom it is even a guiding theme. Boerhaave – and it is true that he is giving an account of the alchemists' thought here – meditates on the symbols of gold (a circle) and silver (a crescent formed by two arcs of a circle, one concave and the other convex). The crescent, he says, denotes 'half-gold; whose inward part turn'd outwards makes pure gold, without anything foreign or corrosive'. Moreover, we can see from this example that pre-scientific thought is closely entwined with symbolic thought. It regards symbols as active syntheses of thought and experience. In a very famous *philosophical letter*[7] printed in 1723 following the edition of the Cosmopolite's work published that same year, we read that 'Anyone who can bring the central virtues of gold to its circumference will come to possess the virtues of the whole Universe in one single Medicament'. There is surely no better way of saying that a material virtue is homologous to an inner psychological power.

There may of course be a contradiction between what this letter calls 'the outside and the inside' of a substance. 'Gold', we read, 'appears and is fixed on the outside, but on the inside it is volatile'. This is a very curious expression that is doubtless infused with personal daydreams for it is hard to see the quality to which this *inward* volatility can correspond. At about the same time, in 1722, Crosset de la Heaumerie writes: 'Quick-silver, though white on the outside ... is red inside ... The red tincture ... appears when it is precipitated and calcined by fire'. Chemists will recognise the oxidation of mercury here and will use this to indicate a *rationalisation* of alchemical thought. The fact remains however that this rationalisation does not in any way correspond to the dreaming thought of alchemists who sought to see matter from the standpoint of inwardness.

If substance has an inside, there must then be an attempt to *search deeply* into it. This operation is called 'the extraction or eccentricity of the soul'. The Cosmopolite says to the mercury that has for a long time been 'scourged and deeply searched': 'Tell me what you are in your centre and I will no longer torment you'. Inside substance 'at the centre of the very smallest atom of metals lie hidden virtues, their colour, and their tincture'. It is pretty clear from this that substantial qualities are thought in terms of inner qualities. From their experiments, alchemists learn secrets rather than any lesson.

Indeed, no kind of direct experience of this centre can be had and a positive mind will realise at once that active properties are of necessity 'superficialised'. Yet the *myth of interiority* is one of those fundamental processes of unconscious thought that are the hardest to exorcise. In our view, interiorisation belongs to the realm of dreams. It can be seen to be especially active in fairy tales. Here, the mind takes the greatest of liberties with geometry. The large can fit into the small. Thus, in one of Charles Nodier's stories a character called the Bean Treasurer can, while carrying three litres of hari-

cot beans over his shoulder, fit into a single chickpea. It is true that this chickpea is the carriage belonging to a little fairy called Pea Flower. In the same way in another story, when Michael the Carpenter has to enter the house of the Crumb Fairy, he exclaims 'Good Heavens! Crumb Fairy ... did it ever cross your mind that we could get into it?' He has in fact just described the house as a pretty cardboard toy. Yet by stooping a little and with the fairy's hand giving him a helpful push, Michael's large frame manages to fit into this small dwelling. He suddenly finds himself with plenty of room and lovely and warm ... Alchemists dream in exactly the same way of the power of their gold when it is dissolved in mercury. Children playing with their little cardboard houses also *dwell* in them with the secure joys of ownership. Storytellers, children, and alchemists all go to the *centre* of things; they take possession of things; they believe in the light of that intuition which puts us at the *heart* of reality. Realist philosophers remove all traces of what is both childlike and precise in this *Einfühlung* and forget the original geometrical sin of the large that fits into the small, and in so doing believe that they can follow the same path and make the same conquests. Just as provident people fill their granaries, so realists store up in substance all powers, virtues, and forces, without understanding that every force is a relation. By filling substance full in this way, they too enter a fairy house.

III

The substantialisation of an immediate quality that is grasped in a direct intuition is no less of a hindrance to the subsequent progress of scientific thought than is the affirmation of a secret or inward quality. This is because it leads to an explanation which is as brief as it is incontrovertible. A substantialisation of this kind lacks the theoretical turn that obliges the scientific mind to criticise sensation. Indeed, for the scientific mind every phenomenon is a moment in theoretical thought, a stage of discursive thought, a result that has been *prepared*. It is produced rather than induced. The scientific mind cannot be content with simply and solely linking the descriptive elements of a phenomenon to a substance, without there being any attempt to establish a hierarchy here and without any precise and detailed determination of relations with other objects.

Direct attribution in accordance with the method used by immediate realism is completely inadequate, and we shall be giving a number of examples in order to make this very clear. We shall thus show the way in which false substantialist explanations are constituted.

Light bodies *attach themselves* to an electrified body: this is an immediate – and moreover very incomplete – image of certain kinds of attraction. The pre-scientific mind turns this isolated image into a means of explanation that is absolute and consequently immediate, even though this image represents only one moment in the total phenomenon and ought not to be accepted into a correct description without its place in it being clearly prescribed. In other words, the immediate phenomenon will be regarded as the sign of a *property of substance*: all scientific inquiry will come to a stop then and there, since the substantialist response stifles all questions. Thus, the electric fluid has the quality ascribed to it of being 'glutinous, unctuous, and tenacious'. Priestley says that 'Mr Boyle's theory of electrical attraction was, that the electric emitted a glutinous effluvium, which laid hold of small bodies in its way, and, in its return to the body which emitted it, carried them back with it'. It is obvious that these rays that go in search of objects, moving outwards and then back again, are parasitical additions. We see then that the initial image comes down to regarding the stick of electrified amber as a finger coated with glue.

There would be no great harm if this metaphor were not *interiorised*; you could always extricate yourself by saying it was merely a way of interpreting and expressing the phenomenon. However, there is in fact more here than just description by a word: there is explanation by a thought. You think as you see and you think what you see: a speck of dust *sticks* to an electrified surface and therefore *electricity is a glue*, a very sticky glue. You have then gone off on the wrong track, where false problems will give rise to worthless experiments whose negative results will even fail to act as a warning because the first, naive image is so dazzling, so blinding, and its attribution to a substance so decisive. When verification fails, there will always be the notion at the back of your mind that a substantial quality that does not appear is still there, masked and hidden. A mind that continues to think this quality in these terms will gradually become impervious to the experimental evidence belying it. Priestley's way of expressing himself shows fairly clearly that he never questions the *glutinous quality* of the electric fluid:

> One James Hartmann, whose account of amber is published in *The Philosophical Transactions*, pretends to prove by experiment, that electrical attraction was really owing to the emission of glutinous particles. He took two electric substances, viz. pieces of colophonia, and from one of them made a distillation of a black balsam, and thereby deprived it of its attractive power. He says, that the electric, which was not distilled, retained its fatty substance, whereas the other was, by distillation, reduced to a mere *caput*

> *mortuum*, and retained no degree of its bituminous fat. In consequence of this hypothesis, he gives it as his opinion, that amber attracts light bodies more powerfully than other substances, because it emits oily and tenacious effluvia more copiously than they do.

Such an experiment is in fact mutilated; to be precise, what is lacking here is the positive aspect. There ought to have been an examination of the product resulting from the refrigeration of the colophonia's empyreumatic[8] parts and it ought to have been noted that the glutinous, unctuous, and tenacious electric substance had concentrated there. This had not been done and for very good reason! Quality has been destroyed in order to prove it existed, simply by applying a table of absence. This is because the substantialist conviction is so strong that it is easily satisfied. This also shows very clearly that this substantialist conviction runs counter to the variation of experiments. Should it find differences in the manifestations of inner quality, it would explain them at once by a variable *intensity*: amber is more electric than other substances because it is richer in glutinous matter and its glue is more concentrated.

We now come to a second and particularly clear example that gives us a good idea of the ravages of direct attribution to substance and of the immediate data of sense experience. In a relatively recent book (dating from Floreal in the year XI[9]), Aldini – Galvani's nephew – gives an account of a letter from Vassali: 'Rossi assured me that the galvanic fluid takes different properties from the live animals and corpses it passes through'.[10] In other words, the substance of electricity is *impregnated* with the substances it goes through. Aldini goes on to say more specifically that:

> I have obtained the following results from successively discharging the same battery through urine – force 5, a very acrid taste, and a white flash; through milk – force 4, a mild, slightly acid taste, and a red flash; through wine – force _, a slightly acid taste; through vinegar – force 2, a sharp taste, and a red flash; through beer – force _, a sharp taste, and a whitish flash ... through a solution of muriate of soda – force 10; in this experiment and the following ones, it was impossible to bear the sensation on the tongue.

This can be easily believed since 'muriate of soda',[11] which is a good conductor, ought to have given a current with a far greater intensity than the preceding liquids which are not such good conductors of electricity. Leaving aside this last precision, let us try to grasp what it was that led to the idea of

electric current having a *taste*. This could only come about by following substantialist suggestions. The electric fluid was considered to be a real material spirit, an emanation or gas. If this subtle matter goes through a tube containing urine, milk, or vinegar, it must be directly impregnated with the taste of these substances. By bringing together two electrodes on the tip of the tongue, you will *taste this material electric current* modified by its passage through different kinds of matter: it will *therefore* be acrid as urine is, or mild like milk, or sharp like vinegar.

If touch is considered in the same experimental conditions, there will be less certainty for touch is duller than taste. Like the monkey in the fable, we do not know why we cannot make distinctions very well but we make them even so. Aldini continues: 'In all these experiments, we had a very different sensation in our fingers ... the sensation presented by the fluid as it passed through sulphuric acid was sharp; that given as it passed through muriate of ammonia ... was of a fatty substance; in passing through milk, it seemed to acquire mildness'. Thus, since milk is mild to the taste and unctuous to the touch, it carries this mildness and unctuousness right into the phenomenon of the electric current that has just passed through it. These false qualities attributed by naive intuition to the electric current seem to us a perfect illustration of the influence of the substantial obstacle.

A better idea of the shortcomings of this sensualist orientation of science will be gained simply by comparing it here, where this particular problem is concerned, with the abstract and mathematical orientation that we believe to be conclusive and correct. The abstract concept Ohm brought into use a few years later in order to designate the different conductors is that of *resistance*. This concept rids science of all reference to *direct* sensory qualities. The objection might perhaps be raised that the concept of a resistance still has too much of an image about it. Linked as it is to the concepts of intensity and electromotive force however, the concept of resistance gradually loses its etymological value and becomes metaphorical. This concept is henceforward the element of a *complex* law, a law that is fundamentally very abstract and wholly mathematical, and that forms a kind of *conceptual node*. It can then be conceived that urine, vinegar, and milk may have specific effects but these effects are registered only through the intermediary of a truly abstract idea, that is to say one that has no immediate meaning in concrete knowledge and no direct reference to primary sensation. *Electrical* resistance is resistance purified by precise definition; it is *incorporated* into a mathematical theory that limits any over-extension of it. Empiricism is therefore *discharged*, so to speak; it no longer has to account at one and the same time for all the sensory characteristics of the substances on which experi-

ments are carried out.

It seems to us that we have just outlined, in half a page or so, the fairly clear opposition between the pre-scientific mind represented by Aldini and the scientific mind represented by Ohm a few years later. Thus, with reference to a particular example, we have just developed one of the principle arguments of this book, namely the supremacy of abstract scientific knowledge over knowledge that is primary and intuitive.

Aldini's substantialist intuition with regard to the galvanic fluid is not an exception. It is normal thought in the eighteenth century. It can be found in a less developed form in many texts, where it is perhaps more instructive because of its very brevity. For example, electric fire is a *substantial* fire. What has to be underlined however is that it is very naturally believed to *participate* in the substance from which it is obtained. Substantial origin is always very hard to exorcise. Writing on electric fire in the *Encyclopédie*, Le Monnier states that the light which comes from rubbed bodies 'is more or less bright in accordance with the nature of these bodies; that of a diamond, of precious stones, and of glass *etc* is whiter, more bright, and far more dazzling than that which comes from amber, sulphur, sealing wax, all resinous matter, or silk'. We have italicised the little word *etc* here because it would merit a long commentary all on its own. And all on its own, it is the mark of an entire way of thinking. Were we dealing with empiricism of a proper kind, one that accumulates and faithfully records experiments that have really been done, we would then have to complete the enumeration. However, the writer is illumined by a *primary and obvious fact*: brilliant and white as these bodies are from the very first in their natural brightness, will they not, when electrified, project a whiter and more brilliant electric fire than that produced by bodies that are opaque and dull? There is therefore no point in going on with the experiment. There is even no point in looking carefully at the experiment and listing all its variables. And there is no point in completing the enumeration: readers will themselves fill in what the *etc* leaves out. Indeed, people think they have hold of the substantial root of the phenomenon they have observed. They do not therefore feel the need to vary circumstances that they consider more or less accidental and more or less superficial. The substantialist answer has once again put an end to scientific questions.

Everything is decided by substantial origin, especially if it has a vital power added to it. In a letter to Zanotti, Pivatti asserts that the sparks he obtains from electrified plants 'are variously coloured in accordance with the nature of the plant, and they nearly always verge on the colour of the flower the plant will produce'.[12] A similar principle of coloration is inscribed in the biological development of a particular plant. Just as flowers are splashes

from the life force, so the *sparkle of fire* obtained, like an electric flower, from plants will allow us to see all the deep and inner tensions of the being it expresses.

IV

In accordance with the method we have established here, let us now examine an instance in which the substantialist obstacle is overcome and thought is consequently corrected, and let us see how inadequate this first correction is.

In the eighteenth century, it was thought to have been observed 'that if the *inner* surface of glass vessels intended for experiments with electricity were coated with substances endowed with medical qualities, then the most subtle parts of these substances passed through the glass with the matter of electricity and together permeated the body and produced in it the most salutary effects'.[13] Here, Joseph Veratti is reporting the theories of Pivatti and Zanotti and he himself undertook precise experiments in connection with this. He purges his servant by placing scammony[14] in the palm of his hand while electrifying him. As a second experiment on a lady gave a less rapid and less clear result, he wonders whether the power of the scammony had been diminished by the first electrification. He therefore recommends that the scammony, spoiled and grown flat because of electrification, should be replaced each time. According to Veratti, purges as indirect as this one work with aloes and gamboge. Veratti sees these experiments as confirming an opinion of Hoffmann's, who attributed the effect of purgatives to 'the most subtle and most volatile particles', *subtlety* being for the pre-scientific mind almost always a sign of power. Pivatti advocates the experiments he had been the first to perform, regarding them as 'entirely harmless and gentle' medication. 'How useful would it not indeed be', he says, 'if in leaving behind bitterness and disgust in the cylinder, we could be sure of taking all their virtues to ourselves by touching them with the tips of our fingers'. This wish is a pretty clear indication of the need to *valorise*. Naturally, such harmless and gentle medication is not limited to purges. Scientific reverie extends it to all diseases and Pivatti has a great assortment of 'cylinders that are diuretic, hysteric, anti-apoplectic, sudorific, cordial, and balsamic'.[15] The Abbé Nollet makes a journey to Italy in order to see such marvels. Unfortunately, in the presence of this French physicist none of these purges 'by participation' meets with success.

We should not be too quick though to rejoice in this reduction of error. Pivatti's theory has a following, even after the Abbé Nollet's criticism. It is

not so easy to put a stop to substantialism's seductive charms. The Abbé de Mangin even lengthens the list of remedies that can be used in electric cylinders. He recommends 'this technique' for the volatile spirit of viper used for the bites of poisonous animals, for the spirit of stag horn as a remedy for convulsions, for orange-flower water in cases of nervous disease, etc ... The objections the Abbé de Mangin raises are to do with protection by medicaments and the number of electric machines 'since each drug would require its special cylinder'. He suggests moreover another technique: impregnate a piece of cloth with the medicament and apply the cloth to the sick part of the body, 'bring to it the virtue of electricity in such a way that because this virtue penetrates the body only through the piece of cloth, it would *necessarily* carry with it what is most subtle and most spirituous in the remedy'. We stress the word *necessarily* here, indicating as it does a valorisation that is independent of the actual experience. But why not just swallow the remedy? This is because it changes its nature when in the stomach 'whereas introducing it into the body by means of electricity is an entirely harmless, gentle, and convenient way of administering a remedy with all its active parts and imperceptibly, so to speak'. How could substances not have innate grace when they are imagined as being so spiritualised, so insinuating, and so valorised by electricity's virtue? Their effective, real action may have been denied, yet even so their affective action still remains. The imagination is at work despite the objections of experience. Once you have given credence to the marvellous, you cannot detach yourself from it, and there was for many years a relentless attempt to rationalise rather than reduce marvels.

V

Every quality calls for its substance. At the end of the eighteenth century, Carra is still in search of a substance that will directly account for *dryness* of the air.[16] Against the aqueous vapours that make air damp he sets sulphurous vapours that make it dry. In the physics of the pre-scientific era, handling negative quantities is, as we can see, no easy matter. The minus sign seems more factitious than the plus sign.

Properties that are manifestly *indirect* for a scientific mind are *immediately* substantified by the pre-scientific way of thinking. Sydenham had to account for the *malignity* of certain fevers and 'made it consist of the development of very hot and very spirituous particles', referring in short to a kind of atom of fever that was charged with fire. Chambon de Montaux quotes Sydenham as follows: 'I think that these hot and spirituous particles acquire great action by coming together; for by the laws of nature, any active principle tends to create substances resembling it: thus it is that fire creates fire and that a liquid which is corrupted by a malign depravation carries infection into the remaining fluids'.[17] This curious idea according to which all active principles create substance is very symptomatic. It seems to us to indicate clearly the tendency towards *direct realisation*, a tendency which we consider can be described as a deviation of the scientific mind. It may be pointed out to us that such a theory of the specific malignity of fevers is a prelude to the discoveries of microbiology. Yet such a 'rationalisation' of scientific history appears to us to ignore the fundamental difference between the two ways of thinking. For the pre-scientific mind *malignity* is directly substantified, with all its phenomenological characteristics: there is a short-circuit from substance to its modes and substantification puts an end to research. On the other hand, microbiology develops through differentiation, by in a way isolating modes from the hidden principle. It is through a lengthy technical process that microbiology finds the specific microbe which allows the specific diagnosis to be perfected. In modern microbiology there is *discursive precision*, a precision correlative to symptoms and causes, which is the absolute opposite of the intuitive substantialism we are endeavouring to describe.

So great is the need to substantify qualities that entirely metaphorical qualities can be posited as essential. Boerhaave thus has no hesitation about attributing mildness to water as its primary quality:

> As a fifth property of Water, we reckon its mildness. And this quality it is endued with to such a degree, that if it is reduced to the Heat of a healthy Body, and then applied to any of its parts, which have the quickest Sense, it not only don't excite any pain, but it don't so much as raise any other than what is caused by the natural humours, and the parts feel when they are perfectly sound. If, for instance, it is applied to the *Cornea* of the Eye, than which there is scarce any part sooner affected with pain from anything sharp, it does not cause the least uneasiness. To the Membrane of the Nose, which is made up of Nerves that lie almost bare, it is neither troublesome, nor affects it with any new smell.

Boerhaave continues as follows: 'And lastly, it demonstrates its excellent mildness, by being able to dilute things acrid, in such a manner as to deprive them of their natural acrimony, and render them harmless, with respect to the human Body'. In consequence of this *essential* property, he says, 'warm Water is esteemed one of the principal Anodynes, and Paregorics in Physic'. It can be seen moreover that even though the quality of *mildness* has gradually moved from one metaphor to another, for Boerhaave it still indi-

cates a quality that is profoundly substantified. And it would be useless to point out the very obvious futility of such thinking.

The play of direct substantifications may of course lead to contradictory attributions in different writers. For Pott, it is not mildness but *hardness* that is water's essential quality. He proves this just as speedily, moreover: 'Water's particles must be very hard since it hollows out the stones and rocks that are exposed to its continual movement. We also know that we feel pain if we strike the surface of the water with the palm of our hand'.[18] Many examples could easily be given of attributions as ridiculous as this. Qualities as external as *sonority* can be enclosed in substance's innermost depths. For Frederich Meyer, proof that the fixed air is an integral element of lime lies in the fact that when lime is melted with sulphur and then cooled, it resounds, the cause of the sound being *acidum pingue*: 'all that comes from fire as a solid body also resounds. Lime, charcoal made from new wood and from bone, some melted salts, metals, both common and metallic glass, porcelain, glass vessels, tiles, and pumice-stones, all of these resound'.[19]

VI

Once the mind has accepted the substantial character of a particular phenomenon it no longer has any scruples about giving in to metaphor. It overlays a particular and often precise experiment with a mass of images drawn from the most diverse of phenomena. In his *Nouveaux Principes de Physique*, Carra explains magnetism like this:

> The phlegm that oozes out of magnets is an effect of the continual pressure or gravitation exerted by this mineral on itself; it is a kind of mercury that, by obstructing the surfaces of the iron and making it impermeable to the ambient air, gives to the elementary fluid alone the faculty of propelling it in (a privileged) direction ... the milky phlegm which emerges from the iron when beaten after smelting is very certain proof that that which oozes out of magnets is not a chimera.

Thus, all substantialist images interact with each other in what they symbolise. The incandescence of the iron on which the blacksmith works is substantified as milky phlegm driven out by an assiduous hammer. This milky phlegm suggests an invisible magnetic phlegm. These two kinds of phlegm, one to do with incandescence and the other with magnetism, allowed the contradiction of the visible and invisible to be transcended. Substantialisation attenuates this phenomenological contradiction. Here, as is so often the case,

substance is thought in order to realise contradictions.

Need we point out once again that the writer quoted here was very frequently quoted at the end of the eighteenth century? He was moreover vehemently attacked by Lalande. We have only to read the note to the reader at the end of Carra's fourth volume to see his skill as a polemicist. In his relations with Lalande he shows himself to be a subtle psychologist, which proves that scientific and psychological maturity do not go hand in hand.

VII

One of the clearest symptoms of substantialism's seductive charms is the accumulation of adjectives around the same substantive: qualities are so directly linked to substance that they can be juxtaposed without too much concern regarding their mutual relations. Here we have a tranquil empiricism that is very far from giving rise to experiences and experiments. It takes the easy way to becoming more refined, just by multiplying synonyms. An example of this has been seen in the glutinous, unctuous, and tenacious character of the electric fluid. It is a general tendency, signs of which could moreover be found in areas far removed from scientific thought, such as psychology and literature: the less precise an idea is, the more words are found with which to express it. The progress of scientific thought comes down in fact to *diminishing* rather than in any way increasing the number of adjectives that fit a substance. Attributes are thought scientifically by being placed in a hierarchy, not by being juxtaposed.

This prolix empiricism is of course at its most apparent in the backward sciences such as medicine. *In the eighteenth century, a medicament is literally covered with adjectives.* These are a few examples among thousands. In the article on antimony in the *Encyclopédie*, we read that 'Golden sulphur is therefore emmenagogic, hepatic, mesenteric, bechic, febrifuge, cephalic, diaphoretic, and alexipharmic'. Elsewhere, spirits of juniper are described as 'sudorific, cordial, hysteric, stomachic, carminative, aperitive, and bechic'.[20] 'Simples' are particularly complex.[21] According to the *Encyclopédie*, knapweed root alone is vomitory, purgative, diuretic, sudorific, expectorant, emmenagogic, alexiteric, cordial, stomachic, hepatic, anti-apoplectic, anti-epileptic, anti-pleuritic, febrifuge, vermifuge, vulnerary, and aphrodisiac, that is to say it has seventeen pharmaceutical properties. Fumitory has seven, sweet almond oil has nine, citron has eight, betony seven, camphor eight, etc.

If the most diverse attributes thus find themselves associated with one and the same substance, then vice versa we should not be surprised to see

many substances co-operating in order to produce one particular remedy. Eighteenth-century apothecaries still use the most complicated of mixtures. The medicated plaster known as 'diabotanum' gathers together a great quantity of plants. If we remember that each one of these plants is itself endowed with many characteristics, we can see how great an accumulation of substances is achieved by diabotanum. The apostles' salve is of course made up of twelve drugs. Malouin's antiscorbutic electuary contains twenty-two simples, and the Abbé Rousseau's soothing balm contains nineteen. The famous polychrest salt that the Seignette brothers consider to be a compound of three salts appears too simple to 'doctrinaire polypharmics'. Theriacs[22] also obey an eclectic substantialism that might serve to symbolise a very particular way of thinking. In a theriac bringing together 150 substances, there is no concern with their proportions; people trust to the efficacy of the ingredients being present and nothing more. A theriac is an accumulation of substances, an accumulation which is never very welcoming. As Maurice Soenen says, 'according to the statutes of La Rochelle the fabrication of theriacs, like that of all large confections in which an infinity of drugs is combined, must be the work of all the masters together, with its product being shared out between them'.[23] The constitution of this *sum of substantial sums* strikes us as very curious. It is a good indicator of the theriac-maker's ideal, which could be compared with the complex of 'saving the pennies' studied by psychoanalysis.[24] This ideal is more persistent than is thought. In 1843, Raspail is still writing like this: 'How many animals are ill when they are deprived of hay, that theriac composed of a thousand balms of different kinds!'[25] For the unconscious, the most composite mixtures are always valorised. The phrase 'everything bellies out' – that is to say, swells and bulges – is just a way of expressing in alimentary terms people's attachment to polypharmic accumulations for protection against disease.

However, since our aim is to arrive at a good description of this myth of medical substances which are overloaded with attributes by the pre-scientific mind – whether this piling-up is seen as natural as in the case of simples, or artificial as in that of theriacs – let us, by way of contrast, look at modern medicaments, which are mass-produced industrially with an ideal of unity and precision. Let us for example compare antipyrine with an old sedative.

If we are to develop this parallel properly, we must disregard the claims made in commercial advertising. Alas, these claims rely in fact on the certainty of finding a pre-scientific kind of support for them among members of the general public. Business readily suggests that tablets can be taken for the most varied of complaints. What is more, people are all too quick to heed what it says. We would be very surprised if we knew all the individual – and

singularly varied – uses to which a modern, chemically well-defined medicament is put. If therefore we disregard, as is right and proper, this antiscientific use of a scientific product and refer to scientific and honourable usage, we shall then understand that there is an attempt here to establish precise correspondence between the nosological entity to be relieved and the chemical entity of the remedy. Modern pharmaceutical science sets its sights on just one quality in substance and no more than that. *The ideal is a monofunctional remedy, a substantive that has a single adjective.* The aim, that is to say, is to *realise a well-defined attribute* by means of substance. Modern pharmaceutical science manufactures a quality rather than a substance, an adjective rather than a substantive. It is *realist* in a discursive way because it *realises* in a movement that is the complete opposite of the classical realism in terms of which modern science could, it was thought, be philosophically described.

This qualitative precision and this state of making absolute distinctions of quality will be very clear if we care to consider certain specific vaccines or serums, all of which are carefully numbered and indicated by sequences of letters that have been very precisely determined. It will then be fully understood that a scientific *product* is a specific and well-defined moment in an objective technique. In order to determine it, we do not put our trust in a more or less hidden, more or less developed activity of substance. We want a well-chosen instant of development and it is this instant that we fix and immobilise in substance. We can indeed say that seen from this perspective of realisations, substance is just the concretisation of abstract theoretical ideas. Without these theoretical ideas we could not *create* substance, for in permanently fixing a property in a well-defined state we are truly creating a substance. We shall be returning to this aspect of modern scientific *realisation* but for now, a comparison between scientific and pre-scientific theories on a very specific point seemed to us a good way of showing both the confused state of pre-scientific substantialism and also the revolution in thinking that has to come about in order to overcome the realist obstacle.

This philosophical question is far more relevant today than it may first seem, because in all educated minds many traces of substantialism still remain and have to be psychoanalysed. The following sentence comes from a treatise on modern chemistry and is one I have used as a test to discern pupils' difficulty in leaving etymology behind and escaping the influence of the *root* word which, in a family of words, always seems to represent a privileged reality. Martinet, the author of this book, simply says that 'Menthol, menthone, and menthyl acetate all smell of mint'. It is not unusual for an educated reader to be heard to say, on reading this line, 'of course they do'.

In this triple affirmation, a triple pleonasm is seen. It seems that the endings – ol – one – *yl* – indicate certain supplementary functions which of course allow the essential quality to remain, that is to say the quality expressed by the root of the word.[26] A reader with no knowledge of organic chemistry is not aware that the derivatives of the same chemical body can have very different properties and that there are functions which, when grafted on to the same central body, do not involve organoleptic properties such as smell. We should indeed point out in passing that, where this example is concerned, a non-scientific mind does not work from the standpoint of *artificial nature*, as is often required. From the standpoint of artificial chemistry, that is to say of scientific chemistry, mint should be said to smell of menthol and not the opposite, when menthol is said to smell of mint. It should also be said, putting our thesis of the supremacy of the abstract rather showily, that 'the concrete smells of the abstract'. It is in fact by studying pure menthol that we can isolate the osmophoric group responsible for smell; it is by studying the molecular structure of this group that we can understand the geometrical construction of a sensory property starting from an abstract schema, or better, the material *realisation* of a smell that has been mathematically defined.

VIII

Educated realism is a reversed realism, the very opposite of which can be seen if we look at the privileged role played by certain crude sensations in substantialist thinking. Taste and smell in particular, with their direct and inward aspect, appear to bring us a trustworthy message from a material reality. The realism of our nose is very much stronger than the realism of our eyes. What to our eyes is smoke that ends in dreams is for our nose and our mouth a wafting smell that leads to meat! The idea of *substantial virtue* is closely linked to smell. Macquer declares it to be so without any discussion: 'A great part of the virtue of plants lies in this principle of their smell, and it is to this that we owe the most singular and most marvellous effects that we see them produce every day'.[27] Nobody questions the need to take great care to prevent pharmaceutical products from going flat and stale due to exposure to the air. While this ought to be a precaution that is specific and relative to certain volatile products, it is however held to be a fundamental principle. It is believed that the *power* of a substance, like that of a flower's perfume, fades and vanishes. If the smell is maintained, then this means that the virtue is safeguarded. We see how simply the substantialism of smells comes to be extended.

Smell is a valorised quality therefore. The fact that a substance somehow bears the sign of a specific smell will help to strengthen belief in the effectiveness of that substance. It is for this reason that Charas is opposed to those who wish to remove the unpleasant smell from viper's salt, for such fastidious people do not understand 'that this smell could not be separated from this salt without its virtue being removed'.[28] Fixing the volatile salt with lime also means making it lose its power – its 'spiritual essence' – because the lime 'petrifies' it. Charas of course offers no proof of these affirmations, his slap-dash logic being as always an indication of a priori valorisations. He has simply and solely therefore substantialised smell. In his view, a primary sensation must not for a single instant be separated from the substance of which it is the sign.

Smells are all pervasive, imposing their presence on us whether we like it or not, facts which mark them out as active realities. Indeed, smells have often been put forward as proof of *individualised realities*. Boerhaave never managed to free himself completely from the idea that every being has an individualising principle, a *concrete* principle that a subtle chemistry can hope to isolate. 'It appears then at length by the help of the chemical Art only', he says:

> that there really is in every single Animal, and Vegetable, a kind of *Aura*, or Vapour, that is proper only to that particular body; and that this is of so subtil a nature, that it discovers itself only by its scent, taste, or some peculiar effects. This Spirit expresses the true genius of the Body in which it resides; and it is this chiefly that accurately distinguishes it from all others. The infinite fineness of this Vapour makes it invisible to the eye, though assisted by the most perfect glasses; nor can the most exquisite Art detain, and collect it by by reason of its vast volatility; When it is pure, therefore, and separated from every thing else, it grows impatient of rest, flies off, and mixes with the Air, and so returns to the grand Chaos of all volatile bodies. There, however, it still retains its own proper nature, and floats about till it descends again with Snow, Hail, Rain, or Dew; it then sinks down into the bottom of the Earth, impregnates it with its prolific seed, mixes with its fluids, and so at last unites itself again with the Animal and Vegetable Juices.

This text shows us very clearly the powerful realism of smell. For Boerhaave, smell is the reality that is the most independent of all our operations. Exhaled by roses on a spring evening, smell returns to the rose bush with the morning dew. It is a reality that transmigrates but that is never destroyed or transfigured. And of course, we cannot create it. For Boerhaave:

> In reality, we find nothing in Nature less imitable by Art, than the fragrant Spirits peculiar to each Plant, which we have in a foregoing passage called the *spiritus rectores* [guiding spirits]; but these, when they are once freed from the tenacity of the Sulphur that entangles and retains them, always, from their own proper nature become volatile, and are dispersed through the atmosphere. How various, then, and how beautiful must be the Effects that are hence produced? And how wonderful must be the grand *Metempsychosis* or transmigration that is by this mean brought about?

Need we stress in passing that modern technology has, from an abstract basis, been able to multiply smells to such an extent that laboratories are more filled with them than gardens are? What is essential to our subject though is to point out the intense valorisation of a particular sensation, a valorisation that is already perceptible in Boerhaave's enthusiastic tone.

The idea that a small substance directs a great one is also very remarkable and shows an easy kind of valorisation. *The guiding spirit* of an oil is 'active'. It is in Boerhaave's view, 'the Son of Fire ... This being generated in the Oils, and held down, and retained in them, endues them with a singular vertue, very efficacious and scarce to be found any where else; And hence, when it comes to be perfectly separated from them, it leaves them vastly less active, nor hardly any longer distinguishable from one another'. This is proof positive of the individualising and consequently very *real* power of material spirits. Conversely, we can understand that an oil deprived of its guiding spirit is considered to be matter that has become stale and flat, without virtue, matter in short that has been *devalorised*.

If we reflect on this highly valued matter that a *Guiding Spirit* is, then we shall no longer be surprised at the importance attributed to *distillation* by the pre-scientific mind. For centuries, this operation provided the researchers' unconscious with a truly technical image of their dreams of transmigration. It was long believed that distillation preserved the specific and essential qualities of the different kinds of matter. The *realism of the quintessence* was not of course subject to even the slightest doubt. The alembic, the mechanism of which strikes us as plainly artificial, was quite often regarded as a piece of apparatus that was somehow natural. Even in the mid-eighteenth century, a writer can still say that 'The brain contained in our heads and placed on the trunk of our bodies, more or less like the cap of an alembic on its cucurbit, will not receive these spirits in the same way by distillation, and therefore the nerves adapted to the brain will not perform the functions here of the beak of the alembic that conveys the products to a receiver'.[29] At the end of the century, other writers form cosmogonies from the standpoint of

distillation and explain the universe in terms of a vast alembic. We know moreover the important part played by the alembic in experiments performed by the *Académie*, which distilled basketfuls of toads, elephant flesh, and the most diverse kinds of matter. We shall not dwell on this point since the futility of pre-scientific distillations has long been known. There is room though for a lengthy study of the alembic. We would be surprised by the number of reveries accompanying the use of this piece of apparatus. We would then understand the great value given to products which are slowly distilled. It would not be difficult here to contrast the technique of fractionated distillations with the former practices of distillers. It would be seen that there is a break rather than continuity between the ordinary and the scientific use of the alembic.

IX

Taste, like smell, can furnish substantialism with primary certainties that are subsequently revealed to be real obstacles to experiments in chemistry. For example while in the later stages of chemistry, acid and basic functions were shown to be principles of coherence that were very useful for a general classification, we must not forget that acid and basic chemical properties were first taken to be attributes directly related to sensations of taste. For this reason, when these inherent attributes – such as sweetness or acidity – came to be masked, attributes which the pre-scientific mind attached to the very depths of substance, people felt the same amazement as they did when witnessing transubstantiation. Many false problems stemmed from a mysterious gustatory impression. Let us turn to consider the summary of an article in the *Histoire de l'Académie Royale des Sciences* in 1667 describing an experiment on 'a sweet salt extracted from very acrid substances'. We read that 'The illustrious Boyle, in his book *De formarum origine*, had proposed a kind of puzzle to all chemists; this was to find a salt which he calls 'Anomal' and which well deserves that name because of its irregular nature. Its taste is sweet, even though it is composed of ingredients more salty or acrid than brine, or more sour than the strongest vinegar'. Du Clos works at solving Boyle's puzzle, we are told: 'He conjectures that this very strange salt is the one spoken of by Schroëder, that is to say a salt which is composed of sweet crystals of common salt, prepared with honey vinegar'. It is not surprising that, after this miracle of conciliating opposite sensory properties, this *Anormal salt* should cure a number of diseases and completely dissolve gold: this is the twofold sign of a *substantial value* bringing, as it often does, fundamental proof of the presence of a substance to a soul eager to possess and a mind

ever desiring to work on a *reality*. A substance is worth something. It is a possession. It is a power that can, and indeed must, show its arbitrariness. Nothing is better at doing this than contradiction. Where Boyle's salt is concerned, even *historical value* is not lacking, as the writer suggests in this reference to the Bible: 'Boyle's puzzle bears some relation to that which Samson proposed to the Philistines, *de forti egressa est dulcedo*'.[30] In our view, this kind of accumulation of valorising thoughts – which we need to point out in passing so as to avoid repeating ourselves – permits us to refer, as we shall do in our next chapter, to the need to psychoanalyse substantialism.

For the time being, let us simply note that a union of sensory contradictions often serves as a reality. Given this example – and we could not wish for anything simpler or more material – we may perhaps understand and judge those philosophical arguments which see reality as being fundamentally irrational. We may even place these philosophies in a converse where accumulating the irrational is sufficient to give an illusion of reality. Is this not how modern novelists proceed, taken as they are to be creators the moment they *realise* illogicality, inconsistency, and miscellaneous behaviour, the moment they mix details and laws, events and projects, originality and character, the sweet and the acrid? This though is not the place to launch into a critique of this fake psychological objectivity. Our only reason for referring to it is to make it clear that the modern novelist is often but a bad chemist and that literary psychology is at the same stage as pre-scientific chemistry.

X

A precious substance must be sought, so to speak, deep down. It is hidden under wrappings. It is submerged amid crude matter and gangue. It is obtained in repeated distillations, extended macerations, and long 'digestions'. Thus extracted, reduced, and purified, it is a quintessence; it is a *juice*. The commonly held ideal which has no difficulty in beguiling substantialist thought is that of possessing in a very small volume the principles of either nourishment or healing. This myth of substantial concentration is accepted without question. Randoin and Simonnet have stressed in their book on vitamins that there is 'a tendency of the human mind since the beginnings of Civilisation to seek to *concentrate* so-called nourishing principles, to remove from them all that appears useless and that must even, so it is imagined, disturb digestive acts'. We shall have other opportunities later on to psychoanalyse this digestive will to power. It may be of interest simply to recall here that nourishment in the form of compressed tablets has in fact been put forward as a human ideal. This shows fairly clearly the valorisation of what

is compressed.

From this point of view, salt is linked to a concentration that can be regarded as typical. After evaporating what is superfluous, the essential and precious matter soon appears in a solution of salt. The myth is of course taken to its limits by the intuition of interiorisation. As Nicolas de Locques says in his *Rudiments*, 'salt is always the innermost part of the innermost part'. In other words, salt is the essence of essence, the substance of substance. There is hence an undiscussed reason for the value attributed to substance. Going without salt sometimes means going without food. 'Whatever its original cause, the superstition of abstaining from salt is encountered more or less everywhere', according to Oldenberg, who gives some examples of fasting from salt in Vedic history.[31]

The ultra-powerfulness of salt is such that it is placed at the origin of life. In another work, Nicolas de Locques has no hesitation in writing that 'Just as earth in the great World is the Magnet, and attracts all celestial influences ... so salt, which is that virginal earth at the centre of all things, is the Magnet of all that can maintain the life of the microcosm'.[32] This *virginal* substance hidden at the *centre* of all things gives us a clear example of matter that is privileged a priori and that is an obstacle to truly empirical thought.

One of the reasons why salt is a privileged substance is doubtless the fact it is used in a small quantity in order to produce great effects. *Homo faber* sometimes works as a pork butcher, curing ham for instance. His intuitions come from his salting-tub. He thinks as he salts. A writer from a fairly distant period, Blaise de Vigenère, has this to say in 1622: 'All the humours of animal bodies, blood, phlegm, urine, and the rest, are salt; without this, everything could become tainted at any moment'. Bernard Palissy makes the same observation in a much more general form and, of course, still without proof. In *Des Sels divers*, he writes: 'If the salt were extracted from beams, joists, and rafters, they would all turn to powder. The same could be said of iron, steel, gold, and silver, and of all metals'. Once a secret power has been attributed to a substance, you can be sure that the valorising induction will know no further bounds. When all these examples are brought together in their unconscious filiation, it can be seen how preserving pork fat by the use of salt leads to the inference that gold can be preserved using a similar and appropriate product.

What preserves can produce. For Vigenère, salt is not 'infertile', but on the contrary it causes fertility. These are the 'proofs' he gives of this: salt provokes the venerean appetite 'on account of which Venus is said to have been born from the sea', and for this reason we give 'salt to animals in order to excite them the more ... again, we see from experience that in ships laden

with salt more rats and mice are born than in the others'. Salt also prevents the earth from turning solid and being constipated, 'this constipation preventing plants from growing'. And finally, after an accumulation of opinions every bit as absurd, Vigenère dares to deduce this key piece of advice from them: 'for these reasons, salt should be decried when holy things are looked upon, for here all lubricity must be banished'. We have no hesitation in transcribing a text so overloaded with foolish nonsense, precisely because it shows the most heterogeneous values sliding together and also the need to attain dominant values, which however have nothing to do with empirical ones.

Sea salt is of course just one aspect of the fundamental salt that lies at the heart of all substances. Should we wish to study the sense of conviction given by these essential valorisations, all we need do is look at alchemical texts. The maxim *Cum sale et sole omnia*[33] recurs in most works. In 1665, Nicolas de Locques is still writing like this in his *Rudiments*: 'Those who work without salt are like those who would shoot their bow without a bowstring or without an arrow'.

It is also as a particularly active substance that salt comes into the theories of palingenesis which enjoyed such great and strange success in the eighteenth century. It is imagined that the ashes of plants and animals can reproduce the beings whose remains they are. For instance, the Abbé de Vallemont writes page after page in order to prove the action of these essential salts.[34] For him, 'The salts contain the ideas, figure, and phantom of the plants from which they are extracted', and 'the seminal virtue of every mixture is concentrated in its salts'. 'This secret', he says, 'teaches us that although the body dies, forms make the ashes their home'.

The consequence of this is that:

> The Shades of the Dead that are often seen to appear in cemeteries are natural, being the form of bodies buried in these places, or their external figure and not their soul ... It is certain that these apparitions can be frequent in places where there have been battles. And these Shades are but the figures of dead bodies that the heat or a gentle breeze excites and raises in the air.

Napoleon II's vision on the field of Austerlitz would therefore have been easily *rationalised* by the Abbé de Vallemont's substantialist intuition.

Lastly, since it is a fundamental trait of valorising thought that every value can be negated, we can find texts in which the properties of salt and ashes are judged in a pejorative way. For Pierre Fabre, for example, the only description salt deserves is this: it is 'grease of the world and thickness of the elements'.[35] It is excrement. Salt is, so to speak, the realisation of impurity.

XI

All patient, rhythmic work, all work that demands a long sequence of monotonous operations, will lead *homo faber* along the path of reverie. He will then blend reverie and song with the matter he is fashioning; he gives high value to substance that is worked on for a long while. The geometrical boundaries of objects are no longer drawn by partial effort and basic movements; when movements are grouped in time, when therefore there is cadence, then there is clear, joyful knowledge. Apothecaries' cheerful energy as pestle is pounded in mortar shows us in itself the value that, very sincerely, they attach to their pills. All this great weight of dreams and all this valorising of substances in terms of the time spent in their preparation must be cleared away from scientific thought. The products of patient work must be devalorised if we wish to psychoanalyse objective knowledge. The difference between a scientific and a pre-scientific mind can be shown fairly clearly here from a very simple example.

For us, trituration is a mechanical process we can immediately understand. This was not the case in the eighteenth century and a fortiori in preceding centuries. It was then a truly polymorphic operation, akin to deep chemical operations. The *Encyclopédie* recalls that for Boerhaave, 'trituration has a marvellous power to dissolve certain bodies and makes them as fluid as if they had been melted by fire'. In the same way, Dr Langelotte can use trituration and make gold 'as fluid as fire does, and make potable gold just by the movement of a mill'. It matters little, as Brunschvicg perceptively points out, that Langelotte thus discovered colloidal gold. He discovered it not for himself but for us, and Brunschvicg refuses, as we too systematically refuse, the recurrent optimism of historians of science who often wish to tack new values on to old discoveries: 'It is not permissible', he writes, 'to say we know a thing we are making while we do not know we are making it'.[36] Here, the value system is different from our way of judging. It is dependent on a mystique of pounding. While pounding is for us simply an incidental preparation for more essential operations, in the eighteenth century it is regarded as an operation providing grounds for sufficient explanation in the most varied of domains. This can be seen if we follow the arguments regarding digestion in the stomach, there being long years of confrontation between partisans of fermentation and those of trituration. The theory of trituration, first proposed by Dr Pitcairn, was an enduring one. As famous a doctor as Boerhaave has no hesitation in writing that: 'In running-footmen, husbandmen, and all persons used to hard labour, fish, and fresh meats, putrify immediately from the violent motion of their Bodies'. The author of the

Encyclopédie article on trituration reminds us of its use by the Hebrews and quotes a verse from the Bible. Saint Paul made a parable of it. The weight of tradition gives substantial experience a supplementary *value* that is no longer current in the formation of a truly scientific mind.

To an operation like trituration, which simply requires patience, we can compare operations simply requiring time, as when things are cooked slowly over a gentle heat. The broths that, in all their variety and particularity, were so much used in eighteenth-century dietetics doubtless owed some of their popularity to the idea that a lengthy cooking-time is an indispensable condition of substantial concentrations.

Yet it is in experiments that are somehow temporally structured that time takes on its full valorising power. Hence the *value* of products obtained in operations that are seven times repeated, so proving the mystic character of this substantialist valorisation. Boerhaave says too that 'fossil copper, as it is dug in the ore requires both exquisite art and labour to make it fit for use; no less than twelve fusions being necessary to render it sufficiently malleable'. However, this precise remark does not involve a description of gradual refinement. In modern chemistry, detailed reasons are given when operations are both long and numerous. *We follow metallurgy as we follow a reasoned argument.* Modern metallurgy is a reasoning process: the abstract theme explains industrial procedures. An operation such as the more monotonous fractionated distillation is entirely arithmetised: it almost proceeds like geometrical progression. The mystique of repetition does not therefore enter a modern scientific mind.

In this respect, an operation like *cohobation* – repeated distillation – must these days seem incomprehensible from every point of view. We know what it consists of: having with considerable difficulty separated volatile from fixed matter in a distillation, you reconstitute the mixture in order to recommence distillation or, as is said in language that is pretty plainly valorising, 'you put the spirit back on to its faeces'. Patience and courage in repeatedly recommencing are a guarantee of value for the end product. Macquer ranks *cohobation* among 'the operations the ancient Chymists performed with great patience and zeal and which are today too much neglected'. Thus, the fact that cohobation had fallen into disuse was not sufficient in Macquer's eyes to take away its value.

XII

When substance is considered without any resistance being offered to unconscious reverie, it readily receives such an intense power to absorb that

it comes to be seen as retaining the properties of the place in which it has dwelt. Eighteenth-century medicine has no hesitation in grounding its choices on a principle as obscurely stated as this. On the subject of broths, the *Encyclopédie* tells us that a stomach weakened by a long period of illness 'is often unsuited to digesting the juice of animals, and does better with that of carp, tench, frogs, etc... which moreover carries a freshness to the blood which we cannot expect to come from the juice of terrestrial or volatile animals'. As has already been pointed out, this kind of enumeration, promptly followed by an *etc.*, shows that substantialist induction has preceded rather than followed specific experiments. This induction is grounded on the wholly substantial explanation of the *juices* that can 'carry their freshness to the blood', a freshness that is obvious when one thinks of the long life lived by fish and batrachians in cold water.

In 1669, the *Académie* dissected a civet-cat in order to compare it to the beaver it had previously studied. These are its conclusions: 'Castoreum[37] has a strong and unpleasant smell while that of the civet-cat is entirely sweet, and it was considered that this difference might come from the cold dampness of the beaver which is a half-fish, whereas the civet-cat is of a hot, dry temperament, drinking little and usually living in the sands of Africa'.

We shall perhaps gain an even better understanding of how misleadingly place leaves its mark on phenomena if we consider experiments that belong to the domain of physics. At the end of the eighteenth century, there was much discussion as to whether frogs from Piedmont were better or worse at demonstrating electricity than frogs from Provence: what a funny kind of objectivity this is that a mountain delimits, with electricity on one side of the Alps and none on the other!

XIII

Generally speaking, all substantial value is interiorised by life, by animal life especially. Life assimilates qualities deep within itself and attaches them firmly to substance. So direct is the connection between the *nature* of an animal and the *natural quality* that the most outlandish affirmations can be sanctioned, under the pretext of idiosyncrasy. In his *Tableau annuel de la Physique* in 1772, Dubois gives an account of his observations of Mignon – Sweetie – a parrot belonging to Madame X, an enthusiastic electrifier:

> All animals have a share of a greater or lesser portion of this virtue of attraction and if it is more perceptible in parrot feathers, this is because the parrot is of a drier and more suitable constitution than other birds. A very

> perceptible proof of this proposition is their natural aversion to drinking. This is often so strong that only a few drops of water will kill them. Hartmann explains this phenomenon in the most ingenious manner. The parrot, he says, always conserves the quantity of electricity proper to it and so cannot fail to be indisposed when it drinks water because it then experiences through the combination of these two things an electric shock that is closely connected to the Leyden experiment.

This is not an isolated example of nonsensical thinking. In a vast book on the diviner's wand, an anonymous writer – doubtless Touvenel – repeats the same thing in 1781 and draws inferences from it:

> We know of birds, for example in the class of parrots, that are eminently electric and that have a natural aversion to water, especially to drinking it ... it is to be presumed that there are many other animals that seek or flee water and its emanations, in accordance with this kind of exquisite sense of the electric fluid. Hydrophobic creatures are perhaps only so because they are indeed in a state of the greatest spontaneous animal electricity, that can be recognised from several symptoms.[38]

The writer sees an explanation here of the phenomena presented by the famous water-diviner Bleton. False sciences conglomerate all by themselves. Bleton was obedient to the physics of his day and ceased to react to hidden springs once glass insulators were placed beneath his feet.

Such arrant nonsense could obviously not find its way into a modern science book, even a popularising work of a highly dubious kind. In the eighteenth century however, it encumbers and hampers culture. There is no hierarchy in the scientific community. All observers are declared equal in the face of experience. All facts can be cited as so many 'anecdotes of nature'. This pulverised empiricism, this kind of concrete experience where there is no attempt at abstraction, extends a ready welcome to each and every individual fantasy. It is enough to find a *particular nature* and a *substantial activity* in order to explain all the particularities of experience and then, by degrees, all the prejudices, all the hearsay, and all the follies of popular wisdom.

XIV

The human being is naturally a privileged factor of interiorisation. It seems that humans can in a direct way both feel and know the innermost

properties of their physical being. The obscurity of *I feel* prevails over the clarity of *I see*. Because their bodies are apprehended in a vague feeling, humans are conscious of being a substance. We shall see how in 1786 the Abbé Bertholon – whose fame has already been noted – explains the action of electricity on human beings at a deep level of substantial inwardness. In *De l'électricité du corps humain*, he writes that:

> There is no truth that is better established than that of the influence of the passions on health; the disorder they bring to the animal economy is so well-known through so many examples that no one can be tempted to doubt it. It would not be at all unreasonable therefore, in order to diminish the effervescence of the blood and the tone of the springs in the entire machine, to recommend the use of negative electricity for those who are victims of the violent passions that perturb and tear the hearts of most people, at least of those who make up a few of society's glittering classes. This means, which is directly opposed to the pernicious effect of the passions, would be very effective in procuring calm and tranquillity, by diminishing the harmful tension all too often caused by the perturbations of the soul; and, taking into account the mutual dependence there is between mind and body, the moral aspect would be weakened by attacking the physical. All these means of preserving health necessarily follow the most certain of principles, and we cannot contest their effectiveness without being very obviously inconsistent.

An extract like this seems to us highly characteristic of the halt to which pre-scientific thought comes when it fastens on to verbal convergences that are reinforced by subjective impressions. Had the word 'perturbation' not been used to describe the effects of passion, then the suggestion of *calming* them with electricity would not have been made. Had the word 'negative' not been used to indicate an aspect of electrical phenomena, then the suggestion of *diminishing* too great a tension in the soul with negative electricity would not have been made. It is plain that in this extract the Abbé Bertholon's thought is working at a linguistic level. The names given conventionally or metaphorically to partial phenomena, to very particular aspects of experience, become full substantives, substances full of substance.

The Abbé Bertholon has no hesitation in designating individuals electrically, in thus giving the mark of electricity a fundamental, truly substantial character. He goes on to state that:

> When it comes to forming the ties of nature without which society could

> not endure, very particular attention must be paid to the electric qualities of temperaments. Two individuals in whom the electric fluid abounds will enjoy less perfect health than if the electric constitution of one of the pair were weak. The same is true of two temperaments that have too little electricity, compared with two others whose electric virtue is unequal; for it is necessary that the insufficiency of the one be destroyed by the excess of the other: the correct balance that comes about in the latter case, even simply through cohabitation, endlessly combats the dominant flaw in temperament. Irrespective of the health that individuals mutually receive through this electric crossbreeding, the State gains from it a population which is more numerous and more strong, just as observation daily confirms to the eyes of the philosopher who keeps watch on nature, which is ever to be admired, even in the most common of all its works.

The idea of *electric wealth* is therefore taken here to be an idea that is clear in itself, having a sufficient explanatory value in the most varied of domains. Here as this electrician writes, we find almost word for word the psychological banalities still current about the usefulness of spouses having contrasting characteristics. Is it to be concluded once again that literary psychology nowadays is at exactly the same stage as electric 'science' was in the eighteenth century? It too is more readily concerned with the passions 'of those who make up a few of society's glittering classes'. Then inwardness is doubtless deeper. A rich personality receives the most diverse characteristics. We see moreover that such facile substantialist intuitions only solve false problems, in the realm of science just as much as in that of literary psychology.

NOTES

1 Bachelard refers here to Molière's use of the sophism 'opium makes you sleep because of its sleep-inducing virtue' in order to mock doctors in his play *Le Malade imaginaire* (*The Hypochondriac*). Bachelard seems to be making the point that if we now say that opium makes us sleep because it is a narcotic, we are indulging in similarly lazy thinking, 'narcotic' being derived from the Greek word 'to induce sleep'; in French, the 'sleep-inducing virtue' – 'la vertu dormitive' – to which Molière and Bachelard refer has a Latin root, *dormire*, hence the reference to two etymologies.

2 Bachelard's footnote: Nicolas de Locques, His Majesty's spargyric Physician, *Les Rudiments de la philosophie naturelle touchant le système du corps mixte*, vol. 1 on theory, vol. 2 on practice (Paris: 1665).

3 Bachelard's footnote: Jean Le Pelletier, *L'Alkaest ou le dissolvant universel de van Helmont, Révélé dans plusieurs traités qui en découvrent le secret*, 2 vols. (Rouen: 1704). In alchemy, the Archeus was the 'servant of nature', that is to say the vital force, the Paracelsian immaterial principle producing and regulating the activities of the animal and vegetable economy.

4 There is some word-play here, the French phrase 'une verge en feu' meaning both a fiery rod and a fiery penis.

5 Bachelard's footnote: Joachim Poleman, *Nouvelle lumière de Médecine du mistère du souffre des philosophes*, trans. from the Latin (Rouen: 1721).

6 In French, the phrase 'to turn someone inside out like a glove' signifies 'to make someone completely alter their views'.

7 Bachelard's footnote: *Lettre philosophique, très estimée de ceux qui se plaisent aux Vérités hermétiques*, trans. from German into French by Antoine Duval (Paris: 1723).

8 'Colophonia' (more usually 'colophony') is the shortened form of 'colophonia resina', resin of Colophon (a town in Lydia), i.e. rosin. Its 'empyreumatic parts' are those in which the heat of the fire remains after they have been burned.

9 This is another reference to the French republican calendar, introduced in September 1792; Floreal was the eighth month of the new republican year, from 20 April to 19 May.

10 Bachelard's footnote: Aldini, *Essai théorique et expérimental sur le galvanisme*, 2 vols. (Paris: 1804).

11 'Muriate' is the old name for chloride, 'muriate of soda' being sodium chloride, i.e. common salt.

12 Bachelard's footnote: Anonymous, *Recueil sur l'électricité médicale, dans lequel on a rassemblé les principales pièces publiées par divers savants sur les moyens de guérir en électrisant les malades*, 2 vols., 2nd ed. (Paris: 1761).

13 Bachelard's footnote: Joseph Veratti, Public Professor of the University of Bologna and Member of the Academy of the Institute of Bologna, *Observations physico médicales sur l'Électricité* (The Hague: 1750).

14 The roots of the plant scammony were used in medicine as a strong purgative; the juice of the plant aloes and gamboge (gum resin from a tree), referred to a few sentences later, were also used as purgatives.

15 Bachelard's footnote: Anonymous: *Histoire générale et particulière de l'électricité*, 3 vols. (Paris: 1752).

16 Bachelard's footnote: Carra, of the King's Library, *Dissertation élémentaire sur la nature de la lumière, de la chaleur, du feu et de l'électricité* (Paris: 1787).

17 Bachelard's footnote: Chambon de Montaux, of the Faculty of Medicine of the University of Paris, Member of the Royal Society of Medicine, Physician at La Salpêtrière Hospital, *Traité de la fièvre maligne simple et des fièvres compliquées de*

malignité, 4 vols. (Paris: 1787).

18 Bachelard's footnote: Jules-Henri Pott, *Des éléments, ou Essai sur la nature, les propriétés, les effets et les utilités de l'air, de l'eau, du feu et de la terre*, 2 vols. (Lausanne: 1782).

19 Bachelard's footnote: Frederich Meyer, Apothecary in Osnabrück, *Essais de Chymie sur la chaux vive, la matière élastique et électrique, le feu, et l'acide universel primitif, avec un supplément sur les Éléments*, trans., 2 vols. (Paris: 1766).

20 Bachelard's footnote: Anonymous, *Chimie du Goût et de l'Odorat ou Principes pour composer facilement et à peu de frais les liqueurs à boire et les eaux de senteurs* (Paris: 1755).

21 'Simples' were medicines or medicaments composed of only one constituent, in particular of one herb or plant; the word also came to signify plants or herbs used for medical purposes.

22 'Theriacs' were antidotes to poisons, in particular to the bites of poisonous snakes.

23 Bachelard's footnote: Maurice Soenen, *La Pharmacie à La Rochelle avant 1803* (La Rochelle: 1910), 67.

24 Bachelard's phrase 'le complexe du petit profit' refers to the French proverb 'il n'y a pas de petits profits', whose English equivalent is 'look after the pennies and the pounds will look after themselves'; in view of his implicit reference to the Freudian notion of anal gratification, it seemed appropriate and in keeping with Bachelard's fondness for word-play to translate this phrase as 'the complex of saving the pennies'.

25 Bachelard's footnote: Raspail, *Histoire naturelle de la Santé et de la Maladie*, 2 vols. (Paris: 1843).

26 The root of the word 'mint' is the Latin *mentha*, to which the French word *menthe* is very close, hence the points made here.

27 Bachelard's footnote: Macquer, of the *Académie royale des Sciences*, *Éléments de Chymie pratique*, 3 vols. (Paris: 1751).

28 Bachelard's footnote: Charas, *Nouvelles expériences sur la vipère* (Paris: 1669).

29 Bachelard's footnote: Anonymous, *Nouveau Traité de Physique sur toute la nature ou méditations et songes sur tous les corps dont la médecine tire les plus grands avantages pour guérir le corps humain*, 2 vols. (Paris: 1742).

30 'Out of the strong came forth sweetness' (*Judges*, 14: 14).

31 Bachelard's footnote: H. Oldenberg, *La Religion du Véda*, trans. (Paris: 1903).

32 Bachelard's footnote: Nicolas de Locques, *Les Vertus magnétiques du sang. De son usage interne et externe pour la guérison des maladies* (Paris: 1664).

33 Literally, 'everything with salt and sun'; figuratively, 'everything with wit and warmth'; the source of this much used maxim appears to be Pliny the Elder's *Natural History*.

34 Bachelard's footnote: Abbé de Vallemont, *Curiositez de la Nature et de l'Art sur la végétation ou l'Agriculture et le Jardinage dans leur perfection* (Paris: 1709).

35 Bachelard's footnote: Pierre-Jean Fabre, Doctor of the Faculty of Medicine of the University of Montpellier, *L'Abrégé des secrets chymiques* (Paris: 1636).

36 Bachelard's footnote: Léon Brunschvicg, *De la Connaissance de soi* (Paris: 1931), 68. Bachelard was much influenced by Brunschvicg (1869-1944), the philosopher of science at the Sorbonne who directed his complementary doctoral thesis of 1927, *Étude sur l'évolution d'un problème de physique. La propagation thermique dans les solides*, and to whom he dedicated it when published (Paris: Alcan, 1928).

37 Castoreum, used in medicine and perfumery, was a strong-smelling, bitter-tasting unctuous substance obtained from beavers' perineal glands.

38 Bachelard's footnote: T*** D. M. M., *Mémoire physique et médical, montrant les rapports évidents entre les phénomènes de la Baguette divinatoire, du Magnétisme et de l'Électricité*, 2 vols. (London: 1781, 1784).

Chapter Seven

Psychoanalysing realists

I

If we wish to try to arrive at a satisfactory description of the seductive charms of the idea of substance, we must not be afraid to seek out their origin in the unconscious itself, where all indestructible preferences are formed. The idea of substance is so clear and simple and so unquestioned that it must rest on an experience lying much deeper within us than any other.

We shall begin therefore by making some observations that will at once seem far-fetched. We ourselves were shocked by them when we began to reflect on the subject. Later, our endless reading of alchemical texts together with the psychological investigations undertaken in the course of our already long and varied teaching career have presented us with such ingenuous substantialist convictions that we no longer have any hesitation in making realism an instinct and in proposing a specific psychoanalysis for it. Indeed, not only is the first firm belief in realism unquestioned but it is also in fact not taught. This means that realism can rightly be called – and this is not in our view a recommendation – the only innate philosophy there is. To see this properly, we need to go beyond the intellectual level and understand that the substance of an object is generally accepted as being a personal possession. People take mental possession of it in the same way that they take possession of some obvious advantage. Hear how realists argue: they have an *immediate* advantage over adversaries because, they believe, they have a hold on reality and *possess the riches* of reality while their adversaries, the mind's prodigal sons, chase empty dreams. In its naive, affective form, the certainty realists feel has its origin in a miser's joy. So as to make our argument clear, let us therefore adopt a polemical tone and say that, from a psychoanalytical standpoint and with naivety taken to excess, all realists are misers. Conversely and here unreservedly, all misers are realists.

The psychoanalysis that ought to be founded in order to cure people of substantialism is the psychoanalysis of the *feeling of having*. The complex to be broken up is that of saving the pennies, the Harpagon complex as it could succinctly be called.[1] It is this complex that draws attention to the little things that *must* not be lost since they cannot be found if they are lost. Thus, a little object is very carefully looked after. A fragile vase is the one that lasts the longest. Do not lose anything is therefore initially a normative prescription. This prescription then becomes a description; it goes from the normative to the positive. Lastly, there is the fundamental axiom of *unproven realism*: nothing is lost, nothing is created, is a miser's saying.

The complex of 'saving the pennies' has already been the subject of many studies in classical psychoanalysis. We shall only deal with it as an obstacle to scientific culture, as giving increased value to a particular kind of knowledge, and as valorising matter and qualities. We are obliged moreover to begin this discussion in a very oblique manner, by putting the emphasis first of all on valorisations which appear to be objective. Thus, it is very certain that in human society precious stones have indisputable material values. However, while accepting that there are grounds for this social valorisation, it is of considerable interest in our view that it can be seen slipping into areas foreign to the initial valorisation, pharmacy being one example of such an area. While this kind of slipping has often been pointed out, the affective nuances of this secondary valorisation have not perhaps been shown. We shall begin by briefly describing this first mutation of values so as to prepare the ground for a study of valorisations that are more clearly subjective. We shall therefore leave it for a while before bringing in texts of which far less notice has been taken but where their authors' heavy, obscure affectivity can be glimpsed. Moreover, we cannot be complete in what we are trying to show here since given the nature of this book, we cannot study psychology *directly*; only a *reflected* psychology is open to us, a psychology that is the result of reflections on the theory of knowledge. It is therefore in the very act of knowing that we must show the disturbance caused by the predominant feeling of having. It is here and here alone – and not in everyday life, even though this could provide us with abundant proof – that we must reveal this direct, unconscious miserliness, the miserliness which despite its inability to count disturbs every calculation. When we come to deal with the animist obstacle, we shall in addition find what may be an even more primitive form of this miserliness in the *myth of digestion*. For a fuller study of the problem, readers can refer for instance to the curious book by R. and Y. Allendy, entitled *Capitalisme et sexualité*.[2]

II

Firstly, it is striking that in pre-scientific research all 'precious matter' has a privileged place over a long period of time. Even when a critical spirit comes into being, it still respects the value it is attacking. We need only glance through the many pages devoted to precious stones in eighteenth-century medical treatises to be convinced of this induration[3] of old beliefs. Our argument would be easier but less meaningful were we to go further back and look at earlier periods. Let us therefore see the pre-scientific mind's *discomfort* when faced with gross prejudice. Even when beliefs are denounced as superstitious, they have to be looked at a second time in order to be sure that the writer is rid of them. Writers first of all feel the need to note these beliefs, for keeping silent here would doubtless disappoint their readers and breach the continuity of culture. Then however – and this is more serious – writers often take upon themselves the task of *partially* rectifying these beliefs, thus bringing about a rationalisation on an absurd basis, as we have already pointed out in accordance with the psychoanalyst Ernest Jones. This partial rationalisation has the same role in empirical knowledge that the sublimation of instincts has in aesthetic production. Here though, rationalisation is detrimental to purely rational research. The mixing together of scholarly and experimental thought is indeed one of the greatest obstacles to the scientific mind. You cannot *complete* an experiment that you have not yourself started all over again in its entirety. You do not *own* a mental possession that has not been acquired wholly by personal effort. The first mark of scientific certainty is that it can be relived in both its analysis and its synthesis.

Let us however offer some examples in which, despite very strong criticism, more or less accurate experience joins up with completely erroneous tradition. In Geoffroy's treatise on medicine – a treatise embodying vast culture and exceptionally well known in the eighteenth century – we read that 'In addition to the superstitious virtues ascribed (to emeralds) and on which we keep silent, it is commonly believed that they stop haemorrhages, dysenteries, and haemorrhoidal flux. They are used with the other fragments of precious stones in the Electuary made of them, and in the Confection of Hyacinth, with hyacinth and sapphires'.[4] There is no better way of saying that superstition is a former wisdom that only needs to be modernised and pruned in order to reveal its true value.

Since there is in fact some truth in this tradition, objections will be raised and answered, with no further attention being paid to positive experiences. 'It may be objected', Geoffroy says:

> that these fragments (of emerald) are so hard that they most often resist *aqua fortis*[5] and that consequently the stomach's leaven cannot dissolve them, returning them just the same as they were when taken. Yet this objection carries no weight. For when an emerald is placed on burning coals, it catches fire like sulphur; and since its green colour wafts away with the flames, it remains diaphanous and colourless like crystal ... Certainly what is done by means of fire ... can be done by natural heat and stomachal lymph. Although the crystalline substance of these stones is not dissolved, the sulphurous and metallic part can however be separated from the crystalline part and being thus released, it can exercise its virtues on the liquors of the human body.

Thus, the medical action envisaged here takes place through the medium of a quintessence, of a tincture that substantifies as it were the most precious part of the precious stone. This virtue is, as we see, presented under the cover of simple *possibility* since no one has ever been able to observe the 'discoloration' of emeralds by the actions of the stomach. It is therefore in our view only a substitute for what is the immediate value, for the pleasure felt when contemplating the emerald's green and gentle lustre. This virtue is equally valorised by pharmaceutical science and by poetry. The apothecary's metaphors have no more reality than those used by Remy Belleau when celebrating the emerald's colour and virtue:

> The colour that summons up and rallies
> Our eyes' strength, weakened
> By gazing too long, too suddenly,
> And that with gentle fires feeds
> Our eye's rays, dull, weary, or blunt,
> When they are scattered.[6]

Thus, the possibilities and dreams at work in the unconscious are enough to make Geoffroy call for respect to be given to ancient wisdom. 'We must not therefore proscribe precious stones from Pharmacy's compositions without good cause', he affirms, 'for they have been accepted for many years and approved by long and blessed patience'. And so we have to respect a science we do not understand! This indeed means that subjective values are being substituted for the objective values of experimental knowledge. Two different evaluations are therefore in play. Doctors who prescribe a preparation of emeralds for their patients already have the surety of knowing that the patient is aware of *value*, of the commercial value of this product. Their medi-

cal authority has therefore only to reinforce an existing value. We cannot overemphasise the psychological importance of the patient's and the doctor's way of thinking being in accord, an accord which was easily achieved in the pre-scientific period. Such an accord confers a particular kind of evidence on certain medical practices, consequently giving them increased value.

It is also very interesting to study the theoretical trappings accompanying the use of *therefore* and *this is why* by people in authority as they together old prejudices and everyday customs. For example, Geoffroy this on the subject of topaz: 'The Ancients ascribed the Sun's nature to it. This is why it is believed to diminish night fears and melancholy, to fortify heart and mind, to be opposed to disturbing dreams, and to check haemorrhages. It is used in the confection of hyacinth'. This psychological and physical bivalence has not been sufficiently studied. We have medicaments that can, through somatic action, alleviate certain kinds of melancholy. We also have psychological medicine. At all events, we no longer give credence to bivalent remedies. This kind of ambivalence is always the sign of an impure valorisation.

Indeed, it must be stressed that where most precious stones are concerned, the pre-scientific mind acknowledges their joint action on heart and mind. This is an indication of the convergence between the joys of both health and wealth. Once a medicament is reputed to check haemorrhages, that is to say when it is believed to help stem the loss of that most precious of possessions, our blood, then it becomes a *restorative* in the full meaning of that word. Geoffroy reminds us of the virtues of cornelian, the colour of which, as Belleau says, is incarnate.[7] 'The Ancients', he writes, 'believed that Cornelian gladdened the heart, that it dispelled fear, brought boldness, prevented enchantment, and protected the body against all poisons. Pulverised Cornelian is taken internally to stop all fluxes of the blood, but it is rarely used today since we have other, far more excellent remedies'. We see that this is by no means a wholesale reservation. A position of compromise is adhered to, showing the resistance there is to healthy scientific methods.

The action of precious matter is sometimes entirely psychological. Sir Kenelm Digby simply says, as though referring to something that goes without saying, that 'Diamonds, garnets, and emeralds ... move the heart to joy'.[8] We have a fairly clear sense of the kind of joy that is being substantified in this way. In addition, Nicolas Papin, who was probably the father of Denis Papin, says rather less clearly that 'sapphires, emeralds, pearls, and other stones incline one to chastity'. Once again, the doctor and the poet coincide, for Remy Belleau also praised the emerald's chastity:

So chaste and holy it is, in short,
That as soon as it feels the touch
Of some amorous action
It is offended, shattering
In shame at seeing itself seized
By some coarse affection.

The Arabs' science deserves of course the same respect as that of the Ancients. Moreover, it is rather curious that even today the Arabic science that brings us meditation on the wilderness should still be looked at in a favourable light. With reference to gold, Geoffroy writes that: 'Formerly, the Greeks knew nothing of the use of Gold in medicine. The Arabs are the first to have commended its virtue; they mixed it in leaf-form into their compositions. They believe that Gold fortifies the heart, revives the spirits, and rejoices the soul; this is why they affirm that it is useful for melancholy, for trembling, and for palpitation of the heart'. In more materialistic centuries, this belief needs to be supported by more material arguments. For this reason, as Geoffroy says, 'Chemists add moreover that gold contains a fixed sulphur of the strongest kind; which being incorruptible, if it is taken internally and mixed with the blood, preserves from all corruption, and it restores and revives human nature in the same way that the Sun, which is this sulphur's inexhaustible source, restores life to the whole of nature'. There can be surely no better example of reasoning by participation, which merges together here in one and the same value gold, sun, and blood. Geoffroy is no doubt reluctant to accept such convergences; however, this reluctance is in fact characteristic of the pre-scientific mind. It is this reluctance that prompts us to say that pre-scientific thought is encountering an obstacle here which, while not yet surmounted, is in process of being so. And it is this reluctance too that calls for psychoanalysis. In previous centuries, there was complete and unquestioning acceptance. In future centuries, these lucubrations will go unread. The facts are there though: writing in the middle of the eighteenth century, Geoffroy declares his respect for the Arab School and cannot bring himself, as he puts it, 'to exile gold from all restorative preparations'.

Exiling gold! How can it be said, calmly and collectedly, that gold does not bring health, that gold does not give courage, that it does not stem the flow of blood nor dispel the phantoms of the night, the burdensome memories arising from the past and from our errors, that gold is not the ambivalent wealth protecting both heart and soul? For this, real intellectual heroism is required, and an unconscious that has been psychoanalysed, that is to say a scientific culture completely removed from any unconscious valorisation.

The pre-scientific mind of the eighteenth century has not achieved this freedom to judge.

It would be easy to give a multitude of examples of these precious medications, such as Charas's Royal Confection of Alkermes and his Panonic powder, Confection of Hyacinth, Powder of joy, and refreshing Powder of Pearls. We would then see that there is a *materia medica of wealth* that is the opposite of the *materia medica of simples*. We would then understand the real importance of the advice given by some apothecaries as fundamental, according to which precious remedies should be kept in boxes made of or silver, ivory or alabaster, or the more modest advice that the boxes be painted and gilded.[9] This is not so much to preserve as to display them effectively, so that everyone, buyers and sellers alike, should be fully in agreement on the remedy's precious value.

There would moreover be no difficulty in showing that refreshing powder of pearls has greater unconscious activity because it represents a more conscious sacrifice. Its valorisation is ambiguous, playing on the border between consciousness and the unconscious. Powder of pearls is more effective for miserly members of the middle classes than for prodigal princes. Pearls and precious stones are so greatly esteemed that there is some merit in grinding them in a golden mortar and dissolving them in a potion. So great is the sacrifice of an objective possession that there is the fervent hope that from this a subjective possession will come. The value of the precious stone for the unconscious is transmuted into a scientific value in the judgement of the educated consciousness. This confusion is still very frequent. A cheap remedy is often held cheap. Yet the unconscious that can count and barter is not the primitive unconscious. Those who, unconscious, dream with pearls in their hands and diamonds on their fingers are souls with heavier burdens. In sacrificing their jewel, it is part of their substance, part of their most cherished dreams, that they are offering up to the fires.

III

We have now reached the point where we need to emphasise and show more directly both the joys of possessing and also the objective security that handling certain substances can bring. A precious stone is small and of great price. It concentrates wealth. It is therefore well suited to concentrating its owner's pleasant meditation. It shows the complex of 'saving the pennies' to be a clear fact. The starting-point of this complex is usually an insignificant object: it is exemplified by Lafitte[10] picking up and saving a pin someone had dropped. This aberration ought not to mislead us however with regard to

the principle of intelligent miserliness, which is to possess much in the least possible volume. This brings us back to the need for a concentration of possessions. Malouin affirms that 'one of the great advantages of chemistry is that it sometimes reduces medicines to a lesser volume without weakening their virtue'. Even today, fifty per cent of radiologists cannot stop themselves telling their patients that a little tube of radium contains a huge sum of money. In the past, alchemists kept their transmutative powder in a small case. They thought of gold as a *concentration* of virtues. We read that 'Gold ... possesses the expanded virtues of the Sun which are compressed into its body'.[11] De Locques also says that in gold, nature 'has gathered together virtues without end'.[12] This last phrase suggests to us that it is the unconscious that finds in gold the occasional cause of all its dreams.

The deep and inward contradiction of small volume and great price is coupled with another, for a precious stone both sparkles and hides itself away. It is at one and the same time both conspicuous wealth and wealth that is concealed, the wealth of both the prodigal and the miser. The myth of hidden treasure is not possible without this condensation of possessions. This myth inspires successive generations. Throughout his life, the father of Villiers de l'Isle-Adam searched for the gold his ancestors had buried. Villiers de l'Isle-Adam *realised* his father's wish by writing *Axel*. Anything rare is found in a secret place. Gold hides itself away just as much as it is hidden by people. The best is what is most hidden. Some alchemists thus saw nature as behaving like a miser. Thomas Sonnet says, though without having any proof of this, that 'nature elects and chooses for the generation of gold a mine or quarry that is particularly enclosed and hidden in the bosom of the earth'.[13]

Thus, gold dazzles and attracts. Is this attraction, this dazzling, metaphorical however? In Malouin's *Chimie médicinale*, published in 1755, we read this: 'In the *Jardin Royal*[14] I have observed a certain joy depicted on the faces of observers at the sight of the gold put before them, before it is dissolved'. I have often made the same observation myself: whenever the time came in the school year to dissolve gold-leaf in chlorine water, I would come up against questions and scruples: would the gold-leaf be *lost*? This death of perfect wealth, of wealth beyond doubt, brought a moment of drama to the classroom. This impassioned interest makes it easier to understand how Malouin can go on to declare with complete confidence that 'Gold (as Mathiole says of Dioscorides) has a certain attractive virtue, by which it lightens the hearts of those beholding it'. This is not a matter of merely drawing on scholarship since Malouin says on his own account that 'gold wonderfully fortifies the heart'. Thus, our eighteenth-century chemist moves imperceptibly from the joy depicted on faces, which is the sign of an ambiguous solace, to

positive tonic action on the noblest of our internal organs. Just one step further and, if we may venture to say so, he will digest his joy in order to remind us in fact that digestion is the sign of the most pleasing and most certain of possessions. Indeed, Malouin writes that gold is 'a good remedy for dysentery'.

Lord Chancellor Bacon, no disdainer of riches, remarks in his *Sylva Sylvarum* that 'what is certain is that precious stones contain subtle spirits, as their brightness shows, spirits which by means of sympathy act on man in an invigorating and delightful manner. Those precious stones that most lend themselves to producing such an effect are diamonds, emeralds, rubies, and topazes'. To understand the full sense of such statements properly, we need to bring together all the reasons for conviction. The joy of possessing is substantified. It gives rise to an inner experience, a solace that renders objective verification completely useless. The order of efficacy is simply and solely an order of personal preference. In opinions of this kind, we witness the union of psychological experience and medical legend, in other words the fusion of a true passion and a false idea. It is the true passion then that is an obstacle to the rectification of the false idea. If we look at readings and teachings which have led to such incredible preconceptions being passed down from one generation to another, the ease and faithfulness with which they were transmitted still has to be explained if we are to justify impure accumulations of this kind. Such preconceptions are in fact endorsed by the immediate agreement of the unconscious.

Attraction to gold naturally becomes, for certain writers, a material attraction. An anonymous author writing in 1640 puts it like this: 'Gold has of itself a magnetic force that attracts hearts by the bright lustre of its pure and shining tincture, wherein Nature has placed the very best she could find'.[15]

We know that for astrologers and alchemists, whose two ways of thinking need to be combined if the psychology of the pre-scientific mind is to be fully understood, astral *influences* are influences that are truly material, that is to say material attractions. We would in particular be making a serious mistake if we thought that these influences were only signs and symbols. Thus, to give just one example, a writer named R. Decartes whose work we have studied in a recent article is of the opinion that: 'The full Moon sends down to the Sea a certain substance that serves as a leaven to it, fermenting it like dough and as it rises causing the ebb and flow of tides'.[16] It is in this spirit that that the correspondence of the Sun and Gold is reified. Thus, Basile Valentin amasses 'proofs' of this physical interaction:

> The Sun and Gold have also a particular correspondence and a certain mutually attractive *virtue* between them, because the Sun has worked in Gold which has served as a powerful mediator in order to unite and bind together inseparably the *three principles* that have their Magnet round this superior Sun, and this *Metal* has obtained such a high degree of perfection that we find there the *three principles* being in very great virtue from which comes the corporeal form of Gold, because it has been composed in the perfect union of these three principles; thus Gold has its origin in the *golden* and celestial Magnet.[17]

If we transcribe such an ill-formed passage it is precisely because there is an accumulation here of the vaguest and most impure impressions. Far from rationalising and classifying proofs, the writer is totalling up values.

Another writer is apparently clearer and yet the same mixture of arguments shows once again the endosmosis of values. For Nicolas de Locques in his *Rudiments* (1665), gold is:

> like a Globe full of all the celestial virtues, that influences all metals just as the heart gives life to all parts of the body. It is esteemed by Universal Medicine because of the sympathy it has with man and with the Sun, and because of the mutual love and attractive virtue there is between them, with the result that Gold is a powerful mediator that binds the virtue of the Sun to man ... Gold cures venereal diseases and leprosy, fortifies the Heart, the Brain, and Memory, and kindles the desire to engender.

The action on heart, brain, and memory shows clearly enough the psychological character of medication by means of gold. Lastly, the action on engendering that countless texts relate is pretty symptomatic of the audacity of an individual whose pocket is bulging with gold.

Yet another writer regards the following comparison as evident: 'Just as the soul warms the animal while it is in the body, so gold drives cold from quicksilver and tempers it while it is truly one with it'.[18] Is there anyone who has not been cheered by a handful of gold just as they are by a glass of wine or a wee dram? Need we recall Balzac's character old Grandet here? In Zola's novel *L'Argent*, the author shows us very perceptively, as Sombart says, 'Saccard continually returning to the place where the gold was hallmarked and where several million gold coins were everyday transformed into gold bars, and listening with delight to the mysterious chinking that gladdened his great speculator's soul: it is the music of gold that hovers over all our business, like fairies' voices in stories'.[19] In our view, this return to *concrete* wealth, wealth far sweeter to the unconscious than the abstractions of bills of

exchange, leaves a deep mark on the soul. This return is a regression.

Feelings are always mutual. Robinet writes this; 'Will people again accuse me of affectation if I speculate that gold, silver, and ... precious stones ... can to some extent enjoy the respect we show them?' He goes on to ask whether 'gold is completely ignorant of the high honour in which it is held'. Robinet also makes a comparison between the luminous carbuncle and the eye that sees light, concluding that 'The faculty of being luminous is assuredly a thing more perfect than that of seeing light'. Indeed, *giving is harder than receiving* and therefore the carbuncle's action has more value than the eye's reception. Here the fundamental principle of substantialism is also very plain, a principle which is at the same time an axiom of avarice: it is that *nullum potest dare quod non habet*.[20] Robinet continues thus: the faculty of being luminous implies 'more purity in the substance, more homogeneity in the parts, and more delicacy in the structure. The soul has been called an invisible light, and the light has been called a visible soul'. We see therefore that the values of object and subject can be inverted. The same conclusion is expressed again in the following: do not stones that sparkle brightly 'enjoy then in their own way the exercise of such a property? Do they not have some consciousness of it? Do they exercise it without the least sense of satisfaction?'. If we invert these images and translate them from the optimistic to the pessimistic mode we shall have, with Schopenhauer's intuition, a metaphysics that will no longer be considered stupid as Robinet's all-pervasive optimism is. Instead of a realism of the joy of giving we shall have that of the will to keep, a desire to live and a desire to possess that are inscribed in the very depths of matter, like an absorbent power. It is this harshness that passes for profound, since it is a feeling that rules the unconscious. Be sad and you will be a philosopher. Robinet's works, on the other hand, now resist reading by the most intrepid of epistemologists. Yet the opinion we now have of such ridiculous works fails to recognise their real and effective importance. The quotations from Robinet here are taken from the third edition of his work. He was, in the eighteenth century, a celebrated and much-read author.

IV

Where gold is concerned, it is easy to see the myth of substantial inwardness, a dominant myth in fact in substantialist philosophy. The Cosmopolite writes as follows:

> It can also be seen from the exact anatomy of metals that within them they partake of gold and that their exterior is surrounded by death and malediction. For firstly we observe in these metals that they contain a matter that is corruptible, hard, and crude, from land that is accursed; that is to say, a filthy, stony, impure, and terrestrial substance that they bring with them from the mine itself. There is secondly a stinking water that can cause death. There is thirdly a mortified earth that is found in this stinking water; and lastly, there is a poisonous quality, mortal and full of fury. Yet when metals are delivered of all these accursed impurities and of their heterogeneity, then we find in them the *noble essence of Gold*.

As we can see, what we have here is in fact a kind of valorisation that goes down to the core, that has to traverse layer upon layer of impurities and poisons, suffering pain and anguish in order to find the supreme value. These are the meditations of the unconscious, as it takes possession of what lies deep within.

Such a profound valorisation, fraught with such enduring dangers, can easily overpraise. In his *Éléments philosophiques*, de Locques expresses the view that:

> Gold being the purest, the most spiritual, the most incorruptible, and most temperate of all subjects; given that nature has enriched it with all the gifts of Heaven and of Earth, and that the Elements lie in gold as in the centre of their perfection; gold being indeed the throne of the general soul, embodying the properties, virtues, and faculties of all things, it is rightly considered to be a universal remedy which contains the virtues of Elixirs and of wondrous quintessences.

Since not one of these powers is proven, we must indeed conclude that they simply reveal unconscious value. Were this value to be devalorised by an appropriate kind of psychoanalysis, then a whole host of false problems facing objective knowledge would be put to flight.

The grounds for valorisation can sometimes be seen in experience. This is clear in the case of diamonds. Their lustre and their entirely phenomenological 'purity' are immediately magnified. Thus, Pivatti says that an electrified diamond 'has a lustre that dazzles, and (that) its flashes represent, on a small scale, thunder and lightning'. We can presume that if diamonds were not highly prized, such exaggerated images would not be attached to them. For Bonnet, purity goes hand in hand with substantial value: 'The Earth', he says, ' that is the base of Rock-crystal and of Diamonds especially, is considered to be among the purest and also as the closest to the primitive Earth'.[21] This affirmation of purity does not of course derive from

an *objective* analysis; its origin is instead a psychological analysis in which the ingenuousness of the joy of gazing has befallen us. This is what leads to the affirmation that the *primitive earth* is without doubt a pure crystal, a bright diamond.

V

Different kinds of precious matter ally themselves together with ease. They give rise to transmutations of values rather than of substances, which is proof in fact of the valorisation of substances by the pre-scientific way of thinking.

Gosset *explains* the mystery of perpetual funerary lamps, lamps that burn but are not consumed and that are said to have been found in certain tombs, in Cicero's daughter Tullia's tomb in particular. In doing so, he offers the following 'anticipation': 'Although I consider precious stones to be matter close to being transformed so as to extract from it a perpetual luminous substance; nevertheless, seeing that they take their fire and their lustre from the tincture of metals, I am in no doubt that from these same metals we can also extract luminous spirits, and principally from those we call perfect, such as gold and silver'.[22] Since gold is incombustible and yet able to be ignited, why could a liquor not be extracted from it which, while giving out both light and fire, would not be consumed? This 'oil of gold', that Gosset thinks will probably be isolated before long, will give us an eternal lamp. The most heterogeneous substantialisations are converging here: the *perpetual* light of precious stones combines with the *immutability* of gold. Nothing can stop realists who pile perfections on a particular reality. Value is the most insidious of hidden qualities. It is the last to be exorcised, for it is to value that the unconscious is most firmly and enduringly attached.

VI

It has often been said that alchemists were sustained in their lengthy work by their desire for wealth. We have put forward a different interpretation in an earlier chapter here, according to which the formal, educational, and moral aspect offers a way of explaining this in psychological terms. Indeed, primitive ways of thinking are ambivalent and we should, for the sake of completeness, bring contradictory arguments together. In other words, the permanence of alchemical experience can be taken to be both a struggle against passions and a struggle for passions. Metzger has rightly said that 'Passions would not go on working towards the same end if they did not find an accomplice in the minds of those who allow themselves to be beguiled by them' (*Les Doctrines chimiques en France*, 102). We could, on other occasions, exactly reverse this and say 'thought would not go on working towards the same end if it did not find an accomplice in the passions of those who allow themselves to be guided by the light of thought'. If we defend one argument to the exclusion of the other, we lose the chance of grasping thought in its precise dynamics, by which I mean its essential discord. Indeed, the dialectic of love of reality and knowledge of reality, which are almost contraries, never ceases to oscillate. Pastor Oskar Pfister has noted that these two contrary tendencies coexist in one and the same unconscious, writing that 'Everyone has within them a tendency driving them to lay hold of the external world and, so to speak, to draw it towards them, making it obey their own ends, and also an opposite tendency that would have them abandon themselves to the outside world'.[23]

There is one theme, a theme to which countless alchemists return, that can show us the superimposition of these two opposite tendencies: this is the declaration that the gold they seek is not ordinary gold. Nicolas de Locques, for instance, says this in his *Rudiments*: 'You can see that my intention is not to speak here of common Gold but of gold prepared in a proud soul as a clarified salt, and in a celestial spirit in the form of a potable liquor'. The sublimation emerging here allows any and every contradiction, and plays upon the theme of the apparent and the real: I look as though I desire riches, as though I am someone greedy for gold; but you need to think again, for what I am seeking is a different gold, an *idealised* gold. Here, sublimation somehow takes place at the level of the object. It is the object that has to provide it with its pretexts. In the same way, all miserliness can be excused by prodigality in the distant future. Going by what misers say, their love of gold is above all a hatred for squandering, a need for order. There are then very many features here that enable us to understand the ambivalence of the feeling of having.

VII

It also seems to us that reasoning by participation equally pertains to a psychoanalysis of the feeling of having. Participation in fact allows the most diverse powers to be piled up on a particular object. The sign alone is therefore endowed with many substantial values.

It would not of course be of any interest at all to point out here the influence of reasoning by participation were we unable to show it to be active in minds that are too quickly categorised as being scientific. We shall

give examples of this taken from Bacon's books, which are literally teeming with them.

In 1785, van Swinden still feels the need to oppose the following *fact* recorded by Bacon, thus proving that prejudices preserved under the cover of a famous name do act as obstacles. Having said that it is well known that warts are cured if the different sorts of matter rubbed on them are left to rot, Bacon is not afraid to vouch for the fact personally. He adds that:

> he had done this experiment on himself: he had had a wart on his finger since childhood, and when he was in Paris he came to have far more of them. The wife of the English Ambassador undertook to cure them by rubbing them with pig fat, which she then hung in the sun outside the window, leaving it to rot there; the operation succeeded in that all his warts disappeared in the course of seven months.

How could one not be cured when the wife of the English Ambassador cares for you with such solicitude! We need only compare this 'reasoning' with some of the 'thoughts' of primitive mentality in order to arrive at a diagnosis of this 'creator of modern empiricism'. This custom that Lévy-Bruhl reports will serve as an example.[24] In order to combat the effect of a poisoned arrow, primitive mentality thinks of *treating* the arrow and not the wound, just as Bacon *treats* the pig fat and not the wart. If the tip of the arrow has remained in the wound it is pulled out and placed in a damp place or else wrapped in cool leaves. You can then expect the inflammation to be slight and to go down quickly. In both cases, as we can see, the objective substance is overlaid with qualities that do not belong to it. Good and evil in particular are very readily taken in by substances. Bacon advises people to carry, in periods of plague, sachets filled with mercury or with arsenic tablets, not, he says, 'because these substances have the property of fortifying the spirits but because being themselves *poisons*, they attract that of the *plague* which has mingled with these spirits, purifying them by this means'.

The primacy of qualities in direct explanation leads to an excessive *realisation* of qualitative *power*. In Bacon's *Sylva Sylvarum* (paragraph 704) we read the following: 'If we could all of a sudden suppress the force of gravity, we would see lead attracted by lead; gold by gold; iron by iron, even without the magnet's help. But this same movement of weight and of gravity, which is inherent and common to matter in general, kills the other, so to speak, unless it is itself destroyed by some violent movement'. It would then be advantageous to use an arrow made of *wood* to pierce *wood*. In order to make a person sweat when in bed, 'bottles filled with hot water' will be used,

which is pretty clearly explicable; what is not explicable is Bacon's added comment to the effect that the result will be better if 'a decoction of sudorific herbs' has been put in the hot-water bottle.

We see moreover that this exaggeration of substantial power is almost irreducible by experience. A mind that prides itself on having *direct* knowledge of the influence of a quality can always find in that quality's nuances a way of avoiding verification. The mind that knows immediately and directly is not far then from the wily, deceitful mind.[25]

If, as we believe, generalised psychoanalysis amounts to establishing the predominance of objective demonstration over convictions that are purely individual, it must look very closely at ways of thinking where proofs are put forward that elude both discussion and checking. It so happens that the best way to avoid objective discussions is to take refuge behind substances, to attribute to substances the most diverse of nuances, and to make them the mirrors of our subjective impressions. The virtual images that realists thus form as they admire the myriad nuances of their own personal impressions are among the very hardest to destroy.

NOTES

1 Bachelard names this complex after the miser Harpagon, the principal character in Molière's play *L'Avare* (*The Miser*).

2 René and Yvonne Allendy, *Capitalisme et sexualité. Le Conflit des instincts et les problèmes actuels* (Paris: Denoël et Steele, 1932).

3 'Induration' is a medical term, indicating an abnormal hardening of tissue; Bachelard's use of it with reference to thought is an example of how he unfixes words from their familiar context. Synonymous with sclerosis, it is also an aspect of his conception of unhealthy thinking.

4 Bachelard's footnote; Geoffroy, *Traité de la matière médicale ou de l'histoire des vertus, du choix et de l'usage des remèdes simples* (Paris: 1743). 'Hyacinth' here is a precious stone.

5 'Aqua fortis' was the early scientific name for nitric acid.

6 Remy Belleau, *Les Pierres précieuses* (1576).

7 'Incarnate' is used in the sense of flesh-coloured.

8 Bachelard's footnote: Sir Kenelm Digby, *Discours fait en une célèbre assemblée touchant la guérison des plaies par la poudre de sympathie*, followed by Papin, Doctor of Medicine in Blois, *Dissertation touchant la poudre de sympathie*, trans. Rault from the Latin (Paris: 1681).

9 Bachelard's footnote: Maurice Soenen, *La Pharmacie à La Rochelle avant 1803* (La Rochelle: 1910), 79.

10 Jacques Laffitte (1767-1844), a powerful banker, helped finance Louis-Philippe's coup d'état in 1830 and was for a short time his finance minister.

11 Bachelard's footnote: *Lettre philosophique très estimée de ceux qui se plaisent aux Vérités hermétiques* (Paris: 1723); see Bachelard's comment on this in Chapter 6.

12 Bachelard's footnote: Nicolas de Locques, *Éléments philosophiques des arcanes et du dissolvant général, de leurs vertus, propriétés et effets* (Paris: 1668).

13 Bachelard's footnote: Thomas Sonnet, *Satyre contre les charlatans et pseudo médecins empyriques* (Paris: 1610).

14 This refers to the *Jardin Royal des Herbes Médicinales*, founded in Paris in 1626, and now known as the *Jardin des Plantes*; with Buffon's appointment as director in 1732, the scope of these gardens was enlarged to include collections of living animals and minerals, and it is to this function as a museum of natural history that the quotation refers.

15 Bachelard's footnote: Anonymous, *Oeuvre de la Physique contenant les trois principes des philosophes* (The Hague: 1640).

16 Bachelard's footnote: R. Decartes, *Les Véritables Connaissances des influences célestes et sublunaires* (Paris: 1667). The article to which Bachelard refers is 'Un Livre d'un nommé R. Decartes', *Archeïon*, 19 (Rome: 1937), now published in the posthumous collection of articles by Bachelard entitled *L'Engagement rationaliste* (Paris: Presses Universitaires de France, 1972), 15-26. He describes Decartes's text as a rare book, held in Dijon Municipal Library and wrongly catalogued as by R. Descartes.

17 Bachelard's footnote omits the title of Valentin's work, giving it as trans. Israël (Paris: 1648).

18 Bachelard's footnote: Gaston Le Doux, called de Claves, *Traité philosophique de la triple préparation de l'Or et de l'Argent* (Paris: 1695).

19 Bachelard's footnote: Werner Sombart, *Le Bourgeois*, trans. (Paris: 1926), 378.

20 'Nothing can give what it does not have'.

21 Bachelard's footnote: Charles Bonnet, *Contemplation de la nature*, in *Oeuvres complètes*, 7 (Neuchâtel: 1781).

22 Bachelard's footnote: Gosset, Doctor, *Révélations cabalistiques d'une médecine universelle tirée du vin avec une manière d'extraire le sel de rosée et une dissertation sur les lampes sépulchrales* (Amiens: 1735).

23 Bachelard's footnote: Oskar Pfister, *La Psychanalyse au service des éducateurs* (Bern: 1921), 109.

24 Bachelard's footnote: Lucien Lévy-Bruhl, *La Mentalité primitive*, 9th ed. (Paris: 1922), 385.

25 Bachelard takes up Pascal's phrase 'l'esprit de finesse' here; Pascal defines this as the mind that sees things immediately and directly, as opposed to 'l'esprit de géométrie', the mind that grasps principles and reasons from them (Blaise Pascal, *Pensées*, section 1, no. 1, in Brunschvicg's edition). While Pascal can be seen as distinguishing here between the intuitive and the logical mind, I have chosen not to translate 'l'esprit de finesse' as 'the intuitive mind' – the phrase used in the English translation by W. F. Trotter, *Thoughts* (New York: P. F. Collier, 1910) – because this now has Bergsonian connotations, preferring to draw on Pascal's definition as more appropriate to Bachelard's reference to direct knowledge. Bachelard also engages in untranslatable word-play here, regarding 'l'esprit de finesse' as close to 'l'esprit de finasserie', 'finasserie' signifying deceitful trickery.

Chapter Eight

The animist obstacle

I

The specific problem that we wish to discuss in this chapter is the following one: how has it been possible to confine the intuition of life to its own realm, this intuition being, as we shall show, an all pervasive one? In particular, how did the physical sciences rid themselves of animist teachings? How was the hierarchy of knowledge re-established by distancing itself from the old regard for that privileged object, our body?

This examination must be a very limited one if it is to be useful. We have in particular no intention of studying life in its real domain; we shall keep away from any critique with reference to the legitimacy of a specifically vitalist intuition when that intuition concerns the phenomena of life itself. Biological knowledge will only hold our attention in so far as it is an obstacle to the objectivity of *physical* phenomenology. Biological phenomena will therefore only interest us in areas where knowledge of them has gone amiss and where this more or less certain knowledge answers questions that have not been put to it. In short, to the almost normal hindrances encountered by objectivity in the purely material sciences there is added the blinding intuition that takes life to be a clear and general *datum*. A general science is then based on this intuition, a science confident in the unity of its object; in a disastrous move, it calls the new biology to the aid of a chemistry and a physics that have already moreover produced positive results. We then see a real fetishism of life being formed, totally scientific in appearance and persisting in periods and in areas where it is astounding that it did not cause outrage. We shall therefore take most of our examples from eighteenth-century science, as has been our more or less hard and fast rule all through this book. It would obviously be far too easy to discern a confusion of the vital and the material in ancient or medieval science. Our work can only be useful if it positions itself at the instant when intuition is divided, when objective thought retracts and becomes more precise, when the scientific mind strives to analyse and distinguish, and when it determines the precise scope of its methods.

II

The best indicator of the status wrongly accorded to biological phenomena is doubtless the importance placed on the idea of the three kingdoms of nature and the key role given here to the vegetable and animal, which dominate the mineral.

It is not unusual for chemists to claim living matter to be *simpler* than matter that is inert. In 1738, Geoffroy takes the opposite direction in his research to what will be the positivist order of complexity. Thus, he states that 'Metallic substances, being closer, more compact, and more tenacious in their texture than Plants and Animals, require longer and more persistent work if we are to separate their principles and recognise their differences'.

There is a tendency for chemists at the end of the eighteenth century – and even at the beginning of the nineteenth – to study organic matter *directly*. In 1788, Lavoisier is still distilling wax, oil, ivory, starch, and meat at the same time as ferric sulphate. In Fourcroy's chemistry, much emphasis is placed on the direct study of organic matter. This is also the case in Berzelius's chemistry.

Everything founded on the analogy of the three kingdoms is always at the expense of the mineral; in the passage from one kingdom to another, it is the aim rather than the cause that is the guiding theme, following therefore a valorising intuition. The correspondence between these kingdoms exercises Lavoisier's mind. 'By what means', he writes, 'does nature bring about this wondrous circulation between the three kingdoms? How does it succeed in forming combustible, fermentescible, and putrescible substances from materials that had none of these properties? These are to this day impenetrable mysteries. We can just begin to see however that vegetation and animalisation must be the inverse phenomena of combustion and putrefaction'.[1] Let us note in passing that this same passage, taken from Berthelot's book, is quoted by Claude Bernard in his *Leçons sur les phénomènes de la vie*. Such views clearly show the level of ill-defined generality at which a celebrated experimenter thinks once he is following the typical themes of a purely biological philosophy. On the firm ground of the study of inert matter, the inverse phenomenon of combustion is not vegetation but *reduction*: the union of carbon and oxygen effected in combustion has as its opposite the separation of car-

bon and oxygen effected by reduction. For an eighteenth-century mind however, vegetation is such a primordial entity that it must be placed at the root of a fundamental chemical process. In the same way, the false dialectic of animalisation and putrefaction is not explicable without the valorisation of life and death.

There is a constant movement between kingdoms even where detail is concerned. The Abbé Poncelet writes that 'putrefaction is to plants what mastication is to animals'. We see only too well that such analogies neither sum up any sure knowledge nor prepare the ground for any useful experiment.

There is also a constant concern to compare the three kingdoms of nature, sometimes with regard to very particular phenomena. What we have here is not simply a matter of analogy but rather a real need to think in accordance with what is imagined to be the *natural scheme* of things. Without this reference to the animal and vegetable kingdoms, one would have the impression of working on abstractions. Thus in 1786, Sage still thinks it necessary to distinguish between igneous glass and animal glass. For him, igneous glass includes vegetable glass, mineral glass, metallic glass, and mixed glass. It can immediately be seen that this dividing-up has begun badly. Sage himself agrees that 'animal glass is in no way different externally from igneous glass'.[2] Distilled however 'with carbon powder, it decomposes and results in phosphorus'. Sage notes again that 'the skeleton of a hanged man has produced twenty-seven ounces of animal glass'. In the same way he distinguishes between different kinds of clay, seeing them as vegetable, animal, or mineral. Clearly then, the three kingdoms are classification principles that have been far too greatly valorised. Everything that life has wrought bears its initial stamp like a value that cannot be disputed.

Such is the need for unity that between the three kingdoms are established analogies and connections – a scale of perfection – that soon lead to the very greatest confusion. In 1785 de Bruno, a fine observer who carefully described countless experiments on magnetic tracings, writes as follows:

> The magnet offers us this particularity of bringing living nature closer to nature that is inanimate; it reveals itself to us in the union of stone and metal, and in the latter this principle of life still spreads out with more energy. This amazing stone presents us with the wonders we marvel at in the fresh-water polyp, that extraordinary plant or rather animal which serves to link the vegetable to the animal kind. The magnet, like this polyp, can be cut in a parallel or transverse direction to its axis, and each new part becomes a magnet ... It is active nature that works in silence and invisibly.[3]

For Bonnet, asbestos marks the transition from crude to organised solids. There is not much difference, he says, between asbestos and truffles. This concern to establish correspondences shows very clearly that people very often think physical phenomena by overlaying them on the more striking and better illustrated phenomena of life.

III

Nature, in all its phenomena, is involved in a general theory of growth and life. In 1722, Henckel published in Leipzig a work entitled *Flora saturnisans* in which he developed the analogy between the vegetable and mineral kingdoms. Such books were not uncommon. They were moreover as immobile as books on general philosophy and in 1760, Henckel's work was still being translated, this time by Holbach. It is the vegetable kingdom that gives lessons in classification and that consequently provides guiding themes. Indeed, Auguste Comte will still be saying that the principles of proper classification cannot be understood unless you have experience of the life sciences, and he will request that philosopher-chemists attend the lessons these sciences teach.[4] This inversion of the order of increasing complexity shows clearly enough the continuing, more or less conscious privilege enjoyed by the phenomena of life.

Everything that imperceptibly grows is ascribed to vegetation. Having found the different kingdoms of nature in the human body, Bordeu in 1768 attributed to the vegetable kingdom our 'nails and the hair on both our body and our head'.

Vegetation seems to be something the unconscious venerates. It exemplifies a tranquil and inevitable becoming. Were we to undertake a systematic study of this privileged image of becoming, we would have a more accurate idea of the standpoint adopted by an entirely animist, entirely vegetable philosophy, a philosophy such as Schopenhauer's in our view.

While generalised animism may be regarded as brilliant philosophy, it seems remarkably impoverished when doctors use it. Thus in 1787, a Bordeaux doctor called Desèze incautiously explains the most diverse phenomena by what Cuvier describes as a:

> particular substance that he calls living substance (and that) circulates in the whole of nature, more or less like the igneous substance of which Buffon had already spoken. Yet the latter only credited his igneous substance with an essential ability to give life; he did not attribute to it life as such.

> Desèze on the other hand insists there is a substance that is itself living and that exercises this property to a greater or lesser degree according to the organisations in which it is employed; this substance circulates in the whole of nature like the substance of fire, and like heat.[5]

This belief in the universal character of life can lead to incredible exaggeration when it comes to be formulated. Cuvier reports that for Caspar-Friedrich Wolf, who qualified as a doctor at Halle in 1759, 'the foetus is not the product of its parents; it is the product of the whole world, and all the forces of nature come together in its formation'. He also reports that Alberti, who was born at Nuremberg in 1682, argues that 'the father becomes thinner when the foetus enters the period of its greatest growth, which is in his view the eighth month, from which time its development is always at the father's expense'. Thus, life is not enclosed within the being it vivifies. It is propagated not just from generation to generation along the axis of time but also in space, like a physical power or a material heat.

The *physical* character of life is attested to by certain intuitions derived from physical phenomena. The writer of the letter to Watson regrets the choice, based on a very specific substance (the Greek word *electron* means amber), of 'the name Electricity for such a wondrous phenomenon that ought properly to be seen as the first principle of nature. It would perhaps have been no bad thing to call it *Vivacity*'. This is not just a word; it is held to be a faithful expression of the intuition of fire and life that *explains* electric phenomena. Hence we have the following extract, which is very typical of the influence of language on thought:

> We generally see that youth has far more of what we call *fire* and *vivacity* than old age does ... Now, if animal life is to be ascribed to the same cause as the fire of electricity, it will no longer be difficult to understand the reason why it is dangerous for old people to sleep beside children: for since an old body contains much less of this fire than a young one does, it is not surprising that it should draw fire from the latter, which therefore loses its natural strength and falls into a state of listlessness, as experience has proved throughout time where children are concerned.

And the writer goes on to reveal, with the same facility and basing himself on a theory of '*vivacity*', how rheumatism comes to humans and blight to trees.

The word 'life' is a magic one. It is a valorised word. When a vital principle can be invoked, all other principles fade into insignificance. The

Comte de Tressan's book – which comes in two volumes, each four hundred pages long – establishes a synthesis uniting all phenomena in the single intuition of *living* matter which commands *dead* matter. It is because the electric fluid is this *living* matter that it vivifies and moves the whole universe, stars and plants, hearts and the germs of all things. It is the source of all burgeoning, of all fermentation, of all growth, for it is 'repulsive unto itself'. In a book like this, it is easy to come upon the intuition of an intensity that is somehow indefinite and inexhaustible, by which the writer condenses a vital *value* on to something infinitely small that is material. Without any proof at all but simply by virtue of the seductive charm of a valorising affirmation, the writer attributes limitless power to elementary parts. Eluding experience is even a sign of power. 'Dead matter', de Tressan says, 'is inert and without organic form; living matter is a million times more tenuous than the smallest molecule of dead matter that the best microscope can enable us to see'. Search as we may through this vast treatise, we shall not find anything to prove this tenuity, nor indeed to justify this substantialisation of life's burgeoning. All there is here is, once again, the seductive metaphors of life. And this intuition is not that of just one writer. The Comte de La Cépède writes in 1781, as though stating an axiom, that 'expansibility does not in any way befit dead matter'.[6] Every upsurge is an upsurge of life, and every force a life force.

Life sets its stamp on the substances that it infuses with unquestioned *value*. When a substance is no longer vivified in this way it loses something essential. Matter that leaves a living body loses important properties. 'This is the case where wax and silk are concerned', La Cépède states, 'and they are therefore non-electricable. Taking this further, wax and silk are in fact simply the excrements of bodies that were once alive'.

IV

Life conceived as a generalised property leads to a philosophical thesis that still has its attractions, provided however that it is not made precise and that it continues to be backed up by a vague sympathy uniting all the beings in the universe. This being so, there will almost certainly be an outcry among philosophers if the *precise* applications of this thesis are called to mind. A deep and wholly respectable conviction is apparently being derided. How different therefore were the periods when the thesis of universal life could be *precisely* stated without any feeling of discomfort! We shall be providing instances of this misplaced precision so as to give a good idea of a state of mind that now belongs firmly in the past. In this section, we shall be putting together a variety of quotations where life is ascribed to minerals. Hélène

Metzger has not omitted to point out this ascription. She has indeed seen that in the seventeenth and eighteenth centuries both chemistry and mineralogy were, as she so well puts it, 'the inorganic overlaid on the living'.[7] This is in effect the argument we ourselves are advancing when we describe the animist intuition as an obstacle where the phenomena of matter are concerned. Our aim in coming back to this problem is to make its extension very clear. The intuition of life has, in our view, an affective character that must be emphasised. It is less *intellectualist* than Metzger thinks. It is also more enduring, for it is found in more recent texts than those that came to Metzger's attention. Where intellectual culture is concerned, the more recent the fault, the more grievous is the sin.

In 1640, in what is indeed a fairly distant period, Guillaume Granger notes a difference between the metals we handle and those that lie in their natural resting-place. When we examine their properties we must, he says, be well aware that they are now 'outside their matrices and their natural places, completely bereft of the care and protection of nature'.[8] In 1664, Nicolas de Locques develops the same theme in his *Rudiments*, saying that 'The diseases of minerals stem from something more distant than the Elements ... they stem also from their form and from the Virtues attached to it, which come to them from the Stars and from a defect in their Matrix'. There follows a lengthy enumeration of these congenital diseases. Again round about the same date, as famous a chemist as Glauber can be seen to share the same opinions. In *Les Doctrines chimiques en France*, Metzger quotes him as follows: metal that is taken out of the earth, he says, 'from which it receives no (more) nourishment, can when it is in this state be very aptly compared to an old and decrepit man ... nature keeps the same circulation of birth and death in metals as it does in plants and animals' (124).

We can find statements every bit as incredible as these much closer to us and in one of the most famous of writers. Boerhaave states that in the islands of Bermuda, the air is such that 'Metals themselves perish there very soon'.

Clear and obvious valorisations lead to very curious moral insights. There are thus many writers for whom rust is an imperfection. Consequently, someone writing in 1735 states that before Adam's transgression 'minerals and metals were without rust, deep within the bowels of the earth'.

The concept of *disease*, regarded as a clear and absolute entity, is applied to objects in the material world. In 1785, well on in the eighteenth century, de Bruno writes as follows in a book recording his often very accurate experiments: 'Rust is a disease to which iron is subject ... Magnets lose their magnetic virtue when rust eats into them. Some of them can be seen to

regain part of their strength when the surface attacked by this disease has been removed'.

In 1737, an anonymous author, who moreover displays a fairly critical mind, writes this: 'There are mines in which still imperfect metals are perfected; indeed, when hollows are found where metallic matter was not entirely formed, these hollow places are often closed up again; in the fullness of time, very rich mines have been found there'.[9] In 1738, the *Académie* puts the whole weight of its authority behind statements that are every bit as precise: we are told that despite the fact that the extraction of gunflints from quarries in the Berry region of France has gone on for many centuries 'there is never a lack of gunflints, for once a quarry has been emptied it is closed up, and a few years later gunflints are found there just as they had been in the past ... Quarries and Mines that had been worked out are therefore again filled up and are still fecund'.

The idea of *production* is so predominant that the simple relation which makes a content smaller than its container is readily contradicted. R. Decartes, who shares a name with the great philosopher, states that the quantity of iron extracted from the mines on Elba is more than enough to make this mountain two or three times as big as it is. Writing in 1682, an author called Dedu speaks of 'mines that do not diminish, whatever the quantity of matter extracted from them, for the surrounding air takes over the mineral's place and acquires its nature. We have several of these mines: there is a saltpetre mine of this kind in the State of Venice and a similar iron mine on the island of Elba'.

Consequently, we must allow the reproduction of metal to keep its mystery and take care not to open up mines too early: 'Were a mine opened up, unfinished metals might be found in it', we are told. 'And because the opening of the mine would interrupt Nature's action, these Metals would remain imperfect and would never be accomplished, and all the seed of metal contained within this mine would lose its power and virtue, in such a way that is would become barren and sterile'.[10]

An important writer whose work was studied by many iron-masters and translated from Spanish into French in 1751 also recalls the fecundity of the iron mines on Elba, adding that from the mines at Potosi are extracted 'stones full of Silver that had been left there some years previously because there was no Silver in them. This happens every day and there is such continuing abundance that it can only be attributed to the action of the Silver's vegetative seed'. Attempts at rationalisation are sometimes to be found, based on easy comparisons. Thus according to Hecquet, 'minerals grow and are reborn in the same way as plants, for if *cuttings* from plants take root, then

when we bury in the earth the fragments of the stones or *diamonds* we have cut, after some years they reproduce other diamonds and other stones'.[11]

It is indeed still possible to make the same statements at the end of the eighteenth century. In 1782, Pott recounts several instances of mineral *fecundity*: 'All these facts', he says, 'prove the successive reproduction of metals, so that the seams that have formerly been worked are, after a certain period of time has elapsed, found to be filled anew with metallic matter'. Crosset de la Heaumerie reports that in some countries 'iron fragments and filings' are scattered in mines that have been exhausted, which means in short that iron is being sown. Having waited for fifteen years after this sowing:

> at the end of this period, a very great quantity of iron is extracted ... There is no doubt at all that such an abundant increase in iron is due to the fact that the old iron put into the earth has rotted and mingled with the seminal ferment of the same mine, diluted by the rains; so that when the seminal essence of the old iron has been dissolved and freed of the bonds holding it prisoner, it acts in more or less the same way as other seeds do, both drawing to itself like a magnet and changing into its own nature air, water, and the salt of the earth, which as time passes are converted into iron.

We have not found similar statements in nineteenth-century books, in spite of extensive research. The myth of the fecundity of mines is clearly at variance with the scientific mind. On the other hand however, it leaves a deep mark on the pre-scientific way of thinking. We shall moreover have occasion to return to this problem, once we have studied the idea of the seed. We shall then be able to prove that the intuition of the fecundity of mines has to do with psychoanalysis. For now, we have only sought to make modern readers feel amazement at the precise way in which the concept of life has been introduced into a area that is manifestly foreign to it.

V

In addition to these general philosophical views, certain kinds of technical progress have been made by giving even greater value to the privileged explanatory role played by biological phenomena. Thus, the microscope was first used to study plants and animals. Life is its original *object*. Only rarely and by accident is it used to study minerals. Here however we can actually see how a familiar occupation can serve as an epistemological obstacle. The question as to whether the microscope reveals an inner structure unknown to living beings leads at once to a curious converse. If the microscope shows

that there is a structure in a mineral, then for a pre-scientific mind this structure is the sign of a life that is somewhat slow and indistinct, dormant or waiting. At times this sign is not deceptive: when the animal origin of corals is discovered, this finding is held to be a perfectly natural one. At other times however this sign sends people in a totally different direction. Let us take the example of Robinet, as he builds conjecture on conjecture:

> On several astroites[12] I have seen fibrous vessels, shaped in small arcs as in the lining of the stomach's ventricle. I would show you a whole host of tubes, hairs, threads, paps, and glandulous clumps in the most compact and rigid bodies, bodies that are said to be in their entirely raw state ... Since the organisation of the solids in an animal body is but the tissue of capillary fibres that are dotted with the glandules composing those solids and which are found there in bundles and lattices, in strands, strips, tufts, arcs, and screws, with different degrees of tension, stiffness, and elasticity, are we not forced to accept as being truly organised bodies all those in which such a structure is found?

The converse to which we have just referred can indeed be seen here, displayed in all its ingenuousness.

With this subtle and learned intuition of microscopic structures as its basis, Robinet's pedantic reverie knows no bounds; it piles up valorisations, as we see from the following:

> Minerals have all the organs and faculties necessary for the preservation of their being, that is to say for their nutrition. They do not have the locomotive faculty any more than plants and some shelled animals such as oysters and barnacles do. This is because they do not have need of it to go in search of their food, which comes to them. Far from being essential to animality, this faculty is in the animals possessing it simply a means to provide for their preservation ... so that those without it can be regarded as privileged Beings, since with one less means they fulfil the same end ... Am I wrong then to regard minerals as privileged in this respect, in that without moving from their place they find their food within their suckers' reach? If they lack food, they suffer and languish and it cannot be doubted that they feel the pain of hunger and the pleasure of satisfying it ... If (the food) is a mixture, they have the ability to extract from it what is suitable to them and reject any tainted parts: otherwise perfect gold or diamonds of the first water would never, or hardly ever, be formed. Moreover, they have like other animals the inner organs required to filter, distil, prepare

and carry their food to all points of their substance.

The microscope's essential valorisation is its discovery of something hidden under what is manifest, of richness under poverty, and of extraordinary things lying beneath the familiar. Microscopes make us cross boundaries. Buffon's hypothesis regarding the molecules of life was almost inevitable, in fact. While there may still be the dualism of matter and life in the higher forms, it is at a minimum in the infinitely small. One of Buffon's followers, the Abbé Poncelet, tells us very clearly how the invention of the microscope has allowed relations – which he considers to be accurate ones – to be established between the living and the inert. We shall see that those who gaze down microscopes still pursue their animist reveries. Poncelet writes as follows:

> Before the microscope was invented, matter was only considered according to a few very vague, very tangible, and very rough relations, such as its extent, its divisibility, its impenetrability, its external form, etc. Since the invention of this admirable instrument however, new and previously unknown relations have been discovered, which have opened up a very interesting field to Philosophy. By dint of varying, repeating, and turning observations in all directions, people have managed to analyse matter almost ad infinitum. They have really seen particles there, distributed throughout, which are ever moving and ever living, and other particles too that are so to speak dead and in a state of inertia. Hence, it has been concluded that matter is essentially endowed with two powers, the one active and the other resistant, that can be regarded as two of Nature's principal agents.

Thus, a gratuitous equivalence is established between activity and life; a quick movement is a sign of *vivacity* and therefore of life. Poncelet continues:

> I have recognised that, amazingly, the movement of these particles appears to be indestructible, since when these living particles seem to lose their movement, as happens when the fluid in which they must swim if they are to be perceived comes to dry up, if they are given a new fluid such as ordinary water ... they are made to arise from their ashes, as it were, and are brought back to life, and are clearly seen to move with the same vivacity they had before their movement was suspended, which may be six months, a year, or two years after their apparent destruction.

Thanks to this animist valorisation of microscopic experience, the Abbé Poncelet is able to say later on that there is 'a great affinity between the living and brute particles of matter: the object of this affinity, inclination, and tendency can only be the preservation of the individual, so that this tendency closely resembles desire'. Here, as we see, we have the intuition of the will to live, put before us more than half a century before Schopenhauer. Its appearance in the context of pre-scientific studies makes it appear superficial however. Yet in both physics and metaphysics, this intuition has in fact the same source, a source which lies in the unconscious. It is the unconscious that interprets all continuity as an inner duration, a will to live, and a *desire* ... The animist intuition continues to both move and convince us as long as it remains a general one. When applied to particles by the Abbé Poncelet, it shows its shortcomings. It would need to be verified there however, were it a matter of objective verification. In reality though it is simply a matter of continuing ancestral reveries with the new images the microscope provides. The fact that people express their wonder at these images at such length and in such literary terms is the best proof that they are dreaming.

VI

We shall try to make our observations more precise by highlighting a complete reversal of ways of explaining. We shall show in fact that at a certain stage in pre-scientific development, it is biological phenomena that serve to explain physical ones. This kind of explanation is not just a matter of referring to a vague intuition of life, to the secret pleasure felt when life is satisfied; it is a detailed development that overlays the physical on the physiological phenomenon. It is not so much the objective mechanism that serves to instruct but rather the mechanism of the body. We shall give many examples of cases where the human body is, in the full sense of these terms, a *piece of physical apparatus*, a *chemical detector*, and *a model of an objective phenomenon*.

Let us begin with an example of a privileged anatomical image. *Veins* and *bodily hairs* seem to us to belong to this category. At the end of the eighteenth century, as skilled an experimenter as Fuss still has intuitions with regard to magnets that were as naive as Descartes's were. Fuss may make the best magnets of the period, patiently varying and multiplying the points of contact, and yet he explains all 'the different workings of magnetism' by the movements of a fluid:

> in the magnet's pores ... which are unanimously conceived as being formed

> by adjacent pipes, parallel to each other and erect; like the veins and lymphatic vessels and other conduits intended for the circulation of the humours in the animal Economy, small hairs or valves, all lying the same way, give free passage to the fluid which flows into the pores following the same direction, and do not on the contrary allow any movement in the opposite direction.[13]

So he rubs his magnets just as he strokes his cat. His theory does not go much further than his action. If the action is more difficult, Fuss intensifies the image: 'the hardest steel', he says, 'resists for a longer time the regular disposition of these conduits, and much more effort is required in order to stir vortices into being here like those that surround natural magnets'. For the Abbé Jadelot, a hair is a very clear objective type, as the following statement shows: 'Iron wire is, as we know, used to give the most high-pitched sounds in instruments with metal strings. It so happens that the high tension of which it is capable seems to indicate that this metal is made of hairs that can be spun and twisted just like hemp'.[14]

In 1785, de Bruno recalls that Huyghens and Hartsoeker believed magnets to be composed of an infinite number of hollow prisms which allowed magnetic matter to pass, adding that 'Euler accepted their view and compared these hollow prisms to the veins and lymphatic vessels found in the bodies of animals'. A scientific mind will question how Euler's comparison can shed light on Huyghens's primary image. The pre-scientific mind will find the animist image to be all in all more *natural* and therefore more convincing. Plainly however, this is a false light.

We now come to an example of a privileged biological phenomenon which is regarded as a principle of measurement. There is such great confidence in the extreme regularity of the laws of life that in some experiments, the pulse is taken to be a chronometer. Bacon brings to this imprecise reference a whole host of precise details that are very typical of the pre-scientific mind. In his *Sylva Sylvarum*, we read that:

> The duration of a flame placed in diverse conditions deserves to be studied. We shall first speak of bodies that burn directly and without the medium of any kind of wick. A spoonful of spirit of hot wine burned for 116 pulsations; the same spoonful, with the addition of one sixth of saltpetre, burned for 94 pulsations, and with one sixth of salt, for 83 pulsations; with one sixth of cartridge-powder, for 110 pulsations; a piece of wax placed in the middle of the spirit of wine burned for 87 pulsations; a piece of flint (!), for 94 pulsations; with one sixth of water, for 86 pulsations, and with

> the same quantity of water again for only 4 pulsations.

Need we draw attention here to the fact that none of these experiments corresponds in either its principle or its way of measuring to a well-defined scientific problem?

Throughout the eighteenth century, many references can be found to the action of electricity on the pulse. It is even argued that two sorts of electricity can be distinguished in accordance with this action. For Mauduit, positive electricity would increase the pulse-rate by a seventh while according to Alibard, negative electricity would slow it by a fortieth, which betokens very great sensitivity. Other writers do not make this distinction, which should underline the lack of objectivity in such measurements. According to Cavallo, 'positive or negative electricity increases the pulse-rate by a sixth or thereabouts'.

A whole book would be required to unravel the argument between the followers of Galvani and those of Volta, between biological and physical electricity. Whatever school they belong to, however, these experimenters all conduct a great number of physiological experiments, and it is these that are of prime interest. Reinhold studied the action of electricity on taste. On the subject of smell, Cavallo (in the words of Sue) 'says that having put together a piece of silver wire, inserted into the nostrils as far as it would go, and a piece of zinc placed on the tongue, he smelled a putrid smell'.[15] The problem thus involves the nose and the tongue rather than silver and zinc.

Reinhold refers to a large number of experiments on sight, stating for example that 'With silver on your right eye and zinc on your left, you see a very bright light'.

An experiment can sometimes be conceived in a scarcely credible form and yet still be repeated by many writers, who may also vary it in really unbelievable circumstances. We shall give just a few examples here. Sue tells us that:

> Humboldt even establishes ... four ways of producing this light (the reference is simply to an impression of light). The most remarkable of these is the one that shows it very clearly, when after placing a piece of zinc on the tongue a piece of silver is inserted deep into the rectum. Fowler says that in addition to the very obvious light, he has seen in his own case and in that of others the pupil of the eye contracting; this seems to him to prove the power the galvanic fluid exercises on the iris.

It will be agreed that this is a very indirect power and that it is rather

hard for us to imagine the importance given to such an experiment. We have also been unable to discover by what circuitous route people came to imagine this experiment, which involves the whole of the digestive tract. This may have come about by virtue of the myth of interiorisation that the phenomena of digestion so well illustrate. Achard repeated this experiment and notes that in addition to the light there is 'a desire to have a bowel movement'. Humboldt repeated it on a linnet, and on frogs and two canaries. So strong was the action that he calmly concludes that 'if a convenient means could be found of covering a large surface of the human rectum with an armature, this would be far more effective than tobacco smoke in bringing back to life those who have drowned'.[16]

When the biological has been valorised, galvanic experiments can be very clearly seen as animist obstacles. Here, complex phenomena are regarded as serving to analyse simple ones. Humboldt has this to say:

> A nerve that is organically linked to a few cubic lines of muscular flesh shows whether two metals are homogeneous or heterogeneous, whether they are in a pure state of regulus[17] or are oxidised; it shows whether the coloration of a mineral is due to carbon or to oxidation. The alloyage of coins is easily determined in this way. When two gold louis or two gold coins minted under the Republic serve as an armature for muscles and nerves in weakened animals, they produce almost no irritation; the same is true in the case of the new gold coins in Prussia. This does not however happen with gold louis in their new state.

Humboldt goes on to note that 'A living nerve fibre shows whether a mine contains metal in a state of regulus or of oxide. It shows whether an organised substance is comparable with animal nature ... It is a living anthrascope, a means of discovering carbon, which is almost as reliable as the action of fire and of alkalis'. Beguiled by this idea, Humboldt allows his thinking to be a little less critical and he comes very close to accepting what has been said of 'Thouvenel's marvellous man who was at one and the same time a living hydroscope, anthrascope, and metalloscope'. Sometimes either the beginnings of a rationalisation or a pretext for rationalisation is all it takes for the most educated of people to accept the 'science' of the magic wand.

Humboldt conducted an experiment on himself in order to prove the specificity of galvanic fluids, so bringing together animist and substantialist intuitions. The precise question he proposes to answer is this: is there an essential difference between the galvanic fluid of some animals and that of

others? This is his answer:

> An iron wire which served to establish communication between the parts of my back where the skin had been bared and had had armatures attached to it produced a very perceptible irritation in the organ of taste of several people present during my experiments. This kind of irritation never occurred when the same experiment was repeated using frogs' legs. Could not this difference be due to the fact that human organs are more readily affected by a fluid emanating from a warm-blooded animal than from a cold-blooded one? Ought we not to suppose that just as all the fluids in a living body differ according to the species of animal, so the very thin fluid that accumulates in nerves and muscles can differ not only in the different species but also in accordance with the sex, age and way of life of the individuals concerned?

This shows that far from leading to an objective study of phenomena, animist intuitions incline instead towards the individualisation of phenomena, accentuating the individuality of substances marked by life.

As is often said in the eighteenth century, 'the human body is one of the most plenteous stores of electric matter'. Aldini regards 'all living beings as so many animal batteries', and believes that the electric fluid:

> has an action on all our liquids and secretory organs, the effects of which are still unknown to us. We might go further and consider all our glands as so many reservoirs of the galvanism that, accumulated in one part more than in another, rendered more or less free, and modified in different manners, gives to the blood flowing all through the glandulous system the means to sustain all the changes it undergoes through the different secretions.

Guided by these animist views, Aldini has no hesitation in affirming that the different substances acting on the human body have an *electric action*: 'opium, quinquina, and other similar stimulants that have much action on the animal system, also increase the battery's effect ... I have made solutions of different stimulants proposed by Brown; I have used these to moisten the pieces of card I placed between the plates of an ordinary battery, and I saw that these substances increased its intensity'. Therefore the human body is indeed the original chemical detector.

The complexity of the animal detector leads to variations being studied that are in fact secondary and even transient. According to Sue, Galvani

operates on animals that are both dead and alive, both cold- and warm-blooded. He finds that 'the animals most likely to show movements of contraction are those most advanced in age'. La Cépède goes further here and declares that 'Bones seem to me to be idio-electric, especially in animals beyond the age of callow youth, in whom they are no longer as soft as they were and are starting to harden'. Writing to Spallanzini, Galvani says that 'animal electricity is not strictly an ordinary electricity, such as that encountered in all bodies, but an electricity that is modified and combined with the principles of life, through which it exclusively acquires characteristics'. We see only too well that the researches of Galvani and his followers were disturbed by the specificity of the biological detectors they used. They were not able to adopt an objective view.

While the movement of the pointer on Coulomb's torsion balance was one with scant mechanical characteristics, for Galvani and his followers muscular contraction was a privileged movement, laden with characteristics and meanings, a *lived movement* as it were. Conversely, it was thought that this biologico-electric movement was more appropriate than any other for explaining the phenomena of life. Aldini wondered whether experiments on electrical contraction 'might not lead to more precise knowledge of the organisation of insects', adding that 'Perhaps they will show us which parts of these animals are especially endowed with contractility'. Aldini recalls the experiments conducted by Zanotti of Bologna: movement and sound are immediately obtained from a cicada that has been killed, and in a little glow-worm 'the phosphoric rings grow brighter and shed a more brilliant light than that which is natural to them ... Large glow worms also shine more brightly and in addition we find a small and very luminous star at the tip of every one of the hairs covering the whole of their body's surface'. Thus, the pre-scientific mind does not follow the path of healthy abstraction. It looks instead for the concrete, for highly individualised experiments.

Electrical problems were however initially formulated on a biological basis and as a biologist, Galvani can be forgiven for continuing the practices of his profession when he encountered phenomena of a new and unknown order. We shall therefore attempt to characterise the animist obstacle according to a more natural theme, examining in a separate chapter the false light cast on objective knowledge by the theme of digestion.

NOTES

1 Bachelard's footnote: Berthelot, *La Révolution chimique*, 2nd ed. (Paris: 1902), 168.

2 Bachelard's footnote: Sage, Member of the *Académie des Sciences, Analyse chimique et concordance des trois règnes*, 3 vols. (Paris: 1786).

3 Bachelard's footnote: de Bruno, *Recherches sur la direction du fluide magnétique* (Amsterdam: 1785).

4 Bachelard's footnote: Auguste Comte, *Cours de philosophie positive*, vol. 3 (Paris: Schleicher, 1908), 50.

5 Bachelard's footnote: Georges Cuvier, *Histoire des Sciences naturelles depuis leurs origines jusqu'à nos jours*, 5 vols. (Paris: 1844-45).

6 Bachelard's footnote: Comte de La Cépède, *Essai sur l'électricité naturelle et artificiel* (Paris: 1781).

7 This phrase plays on Bergson's definition of the comic in *Le Rire* (1900) as 'the mechanical overlaid on the living'; see *Laughter*, trans. Cloudesley Brereton and Fred Rothwell (London: Macmillan, 1913), Chapter 1, section 5.

8 Bachelard's footnote: Guillaume Granger, a Native of Dijon, Physician to the King and to his Royal Brother, *Paradoxe que les métaux ont vie* (Paris: 1640).

9 Bachelard's footnote: Anonymous, *Nouveau Cours de Chymie suivant les principes de Newton et de Stahl*, new ed. (Paris: 1737).

10 Bachelard's footnote: Anonymous, *Le Traité d'Alchymie et le Songe verd* (Paris: 1695).

11 Bachelard's footnote: Anonymous, *De la digestion et des maladies de l'estomac, suivant le système de la trituration et du broyement, sans l'aide des levains ou de la fermentation, dont on fait voir l'impossibilité en santé et en maladie* (Paris: 1712). Bachelard adds that the author is Hecquet.

12 An astroite is defined as either any star-shaped mineral or fossil, or a species of madrepore (a coral); the latter seems more appropriate here.

13 Bachelard's footnote: Nicolas Fuss, *Observations et expériences sur les aimants artificiels, principalement sur la meilleure manière de les faire* (St. Petersburg: 1778).

14 Bachelard's footnote: Abbé Jadelot, *Mécanisme de la Nature ou système du monde, fondé sur les forces du Feu, précédé d'un examen du système de Newton* (London: 1787).

15 Bachelard's footnote: P. Sue, *Histoire du Galvanisme*, 4 vols. (Paris: 1805).

16 Bachelard's footnote: F.-A. Humboldt, *Expériences sur le Galvanisme et en général sur l'irritation des fibres musculaires et nerveuses*, trans. J.-F.-N. Jadelot, Physician (Paris: 1799). An armature is the movable part of a dynamo or electric motor; it consists of a coil or coils, usually rotating.

17 Regulus is defined as the purer or metallic part of a mineral, which is not yet malleable.

Chapter Nine

The myth of digestion

I

Digestion is a function that is privileged, a poem or a drama, a source of either ecstasy or sacrifice. It therefore becomes an explanatory theme for the unconscious, one to which immediate, unshakeable value is given. It is often said that optimism and pessimism are to do with our stomachs. Yet we do aim to be either good or bad-tempered in our social relationships: it was in his dealings with humankind that Schopenhauer sought reasons for upholding his system or, in his own so obviously symptomatic phrase, *food for misanthropy*. In fact, knowledge of objects and knowledge of human beings come under the same diagnosis and, in some aspects, *reality is initially a food*. Children put objects in their mouths before they know what they are, and so as to know what they are. The sign of well being or of discomfort can be erased by one that is more decisive, by in effect the sign of realist *possession*. Indeed, digestion corresponds to taking possession of a fact that is more obvious than any other and whose certainty cannot be questioned. Digestion is the origin of the strongest kind of realism and of avarice at its most acquisitive. It is indeed the function of animist avarice. Its entire coenaesthesia[1] lies at the root of the myth of inwardness. This 'interiorisation' helps us to postulate an 'interiority'. Realists are eaters.

This function of possession, which only needs to be pointed out for it to be seen as an obvious fact, is very clear in some pre-scientific texts. De la Chambre, for example, gives increased value to the appetite which he in fact understands as possession, as we see from the following: 'taste is in the mouth and at the gate ... but appetite is in the place receiving what has entered. Since possession is the aim and goal of appetite and since those who would possess must desire, the stomach that is to receive the food must therefore also have had an appetite'.[2]

This possession is the subject of a whole system of valorisation. Food that is hearty and substantial is given immediate value. Drinking is nothing in comparison with eating. If the intellect develops by following the hand that lingers over solids,[3] then the unconscious takes deep root by feasting on chewy, doughy things. This privileged status of the hearty and the doughy can easily be seen in everyday life. We can also see signs of it in many pre-scientific books. For Hecquet, the anonymous author of a *Traité des dispenses du Carême* published in 1710, while hunger is utterly and entirely natural, thirst is always against nature, '*febricantes sitiunt, esuriunt convalescentes*'.[4] 'Hunger', he says, 'comes from a vigorous stomach, that feels its strength and excites it, empty as it is of juices but full of energy ... thirst comes from the inaction of the nerve fibres that dryness stiffens and renders powerless to move'. Hunger is therefore the natural need to *possess* food that is *hearty*, *enduring*, *integrable*, and *assimilable*, and a true reserve of strength and power. Camels no doubt keep a reserve of water for their desert-crossings and he surmises that 'they may still have the instinct to stir up water before they drink it, so that being more muddy and heavy it will stay in these reservoirs for longer and pass into the stomach later'.

The contradiction of values is of course not far away when thought is from a valorised perspective. However, although this contradiction may appear to concern rational elements, it in fact simply exists in the dialectic of taste and distaste. The eighteenth century's long polemic on the subject of pap, gruel, and the like is very instructive here. Emulating Rousseau, Diderot writes an article on pap in the *Encyclopédie* offering health advice that is an odd mixture of scientific verbiage and unconscious valorisation. 'It is common practice', he writes, 'to feed children up in the first two or three years of their lives with a mixture of flour and milk, which is then cooked and which is known as pap. There is no method more harmful than this'. He then proves it pedantically as follows:

> Indeed, this food is extremely coarse and indigestible for the internal organs of these little ones. It is a very real kind of glue, a sort of mastic that can block the narrow paths taken by chyle in order to enter the bloodstream. Most often this food serves only to obstruct the glands of the mesentery because the flour composing it has not yet fermented and is liable to turn sour in children's stomachs, which it therefore covers with mucus, causing worms to breed there that afflict children with many diseases endangering their lives.

It takes all these reasons, deductions, and inferences just to tell us that

Diderot does not like pappy food! Nothing has more *reasoned* consideration given to it than food does among members of the middle classes. Nothing else bears such a mark of the substantial. Whatever is substantial is nourishing. Whatever is nourishing is substantial. In his *Traité physiologique et chymique sur la nutrition*, a work awarded the physics prize of the Berlin Academy in 1766 and published in Paris the following year, Durade remarked very simply on this axiom of substantial digestion: 'one single substance nourishes; the rest is but a condiment'.

One of the most persistent myths we can follow all through scientific times, where it is always served up in terms of the science of the day, is that of the assimilation of similar things by the digestion. The best way of showing this to be a preconceived idea is to take a writer from the fairly distant past. Writing in 1636, Pierre-Jean Fabre, the Montpellier doctor, says in his philosophical language that 'If the food is in its beginning different from what it feeds, then it must divest itself of this difference, and by divers alterations must make itself to be similar to what it feeds, before it can be its last food'. Modern nutrition has not however advanced much beyond this text in its ideals and remains every bit as *materialist*. Children are stuffed with calcium to do their bones good without the problem of assimilation ever being thought about. Even when an experience is real, it is thought from an erroneous philosophical perspective. There is always the tendency to make the similar attract the similar, to see the similar as needing the similar in order to grow. Such are the lessons of this digestive assimilation, lessons that are of course drawn upon when inorganic phenomena are being explained. This is exactly what Doctor Fabre does when he develops an entire course on chemistry and general medicine based on the fundamental theme of this digestive assimilation.

II

Valorisation leads to the stomach being given a primary role. It was known in antiquity as the king of the internal organs. Hecquet speaks admiringly of it, even though in his theory it was but an organ whose job was to triturate food. But what a marvel it was, even so! He describes it as 'This animate, philosophical millstone that grinds without noise, melts without fire, and dissolves without corrosion, all this by a force as surprising as it is simple and gentle; for though it surpasses the power of a prodigious millstone, it works without fuss, operates without violence, and stirs without causing pain'. In 1788, Roy Desjoncades may be content to admire the stomach's *site*, his enthusiastic tone is obvious:

> The situation of the stomach, that vessel of digestion, its form and diameter, the thickness of its walls, the helpers placed around it, everything here is arranged in a symmetry of the most regular kind, in order to favour and maintain this vital heat ... The organs, muscles, and trunks of arteries and veins surrounding it are like so many burning coals maintaining this fire. The liver covers and warms it on the right side, and on the left the spleen does the same. The heart and diaphragm fulfil the same role above it. The abdominal muscles, the epiploon and the peritoneum bring it heat from in front, and behind it the same service is rendered by the trunks of the main artery and of the vena cava, together with the muscles of the spinal column.[5]

This valorisation of stomachal heat is also very instructive in itself. It is very frequent in texts of the pre-scientific period. In the *Histoire de l'Académie des Sciences* for the year 1673, we find the following passage:

> Our stomach makes extracts from Plants as fire does, and changes them no less. From wine, for example, it draws a spirit that rises to the head, and subsequent digestion yields combustible parts and volatile sulphurated substances. Yet what is most remarkable and most happy with regard to the relation of the operations of the stomach to those of Chemistry is that we can see from several examples that it either forms or releases by its gentle, damp heat alone the same substances that Chemistry can only have by means of a great fire. This is the only way that from Emetic Powder, seemingly insipid as it is, aerated substances can be drawn; and from it the stomach draws the same substances, easily and gently, the only substances in fact that can irritate and upset it.

Where there are differences between the chemistry of the stomach and 'artificial chemistry', it is of course always the former, in vivo, that is held to be the most natural and consequently the most skilful of the two.

This brings us to the *pivotal* property upon which the pre-scientific mind endlessly turns: digestion is a slow, gentle kind of cooking, and therefore any cooking that goes on for a long while is a kind of digestion. We can never devote too much time to reflecting on this converse if we wish to understand the direction taken by animist thought. This is no mere metaphor. For the pre-scientific mind in fact, chemistry learns by examining the phenomena of digestion.

First, there is the *form* of the human body, which surely follows that of an oven, properly understood. In a text going back a fair way to the end of the sixteenth century, Alexandre de La Tourette artlessly tells us his reverie:

> We see too how this very excellent alchymist, our Lord God, has built his oven (which is the body of man) with such a fine and proper structure that nothing can be said against it. It has its air-vents and necessary registers, which are the mouth, nose, ears, and eyes, so as to preserve within this oven a temperate heat and its continual fire, aerated, clear, and well regulated, in order to perform there all His alchemical operations.

Digestion is, according to one eighteenth-century writer, 'a small conflagration ... the food must be in proportion to the capacity of the stomach just as a bundle of firewood is to that of the fireplace'.[6] The current way of expressing the value of food in terms of calories is not necessarily any better suited to the reality than are these simple images.

For the pre-scientific biologist, the degrees of stomachal cooking suffice to specify substances. The same writer also declares: 'Be persuaded that between milk and chyle ... the only difference is in the degrees of a more or less advanced process of cooking or digestion'.

Not for nothing was the pot Papin used, which was in fact a real cooking pot placed in a hay-box, called Papin's digester. It was by thinking about the stomach's work that its phenomena were explained. Indeed, what was especially striking was the fact that when meat was cooked on a very low heat for some six to eight minutes:

> it was reduced to a pulp, or rather to a perfect liquor; by increasing the heat, or simply by leaving it as it was for a few more minutes, the hardest bones were transformed into pulp or jelly. This effect can be attributed to the exactness with which this machine is closed up; since it does not permit air to either enter or leave it, the jolts occasioned by the expansion and oscillations of the air enclosed in the flesh are uniform and very vigorous.[7]

We recognise the theory of stomachal trituration here. In addition, the writer says that: 'This appears to be perfectly analogous to the operation of the stomach; for although this organ does not usually dissolve things so rapidly or so thoroughly, nevertheless in proportion to both its heat and its construction, Drake considers the effect to be entirely the same'.

In order to defend the theory of stomachal trituration, Hecquet reminds us that what makes for the goodness, delicacy, and soundness of chocolate is the fact that it has been properly ground. 'Pastry-making would furnish a million other (proofs) of this', he tells us, 'for from the same flour, seasoned in the same way but differently stirred and kneaded, it makes different dishes.

We should perhaps omit this detail, which philosophical minds usually find unsatisfactory, for nothing touches them other than the sublime or the marvellous'. This manner of arguing is a clear indication of the *continuity* going from cooking to digestion. It has often been said that digestion begins in the kitchen, and we would add that learned theories also begin there. Where the biological intellect is concerned, *homo faber* is a cook.

Operations that really do not have any importance for us were formerly marked by the myth of digestion. The *Encyclopédie* still refers under the word 'buccellation' to an 'operation by which, in order to be worked, different substances are divided up into pieces, as though by mouthfuls'. The animist history of a chemical operation has thus begun in the mortar itself. For as long as this work goes on, the metaphors of digestion will sustain objective thought: physical experiment takes place from the perspective of biological experience. Some alchemists even give the idea of feeding its full force and its precise meaning when they are in fact working on matter. Using the word 'cibation', they maintain that they are helping a reaction by feeding it with bread and milk. In 1722, Crosset de la Heaumerie is still referring to 'feeding and suckling a compound'. While this is sometimes an image, it is at other times a reality, with milk being poured into the retort. Indeed, so confused is animist intuition that any white powder can serve as flour. Thus, writing in 1742, one author unequivocally acknowledges that some minerals have the properties of flour. Certainly, 'all these different kinds of flour are not equally nourishing', he says, but with water, such flour 'becomes a kind of milk. The very milk we take from cows ... is not a different liquor'. It is very plain therefore that the concept of *nourishing food*, which is so clear and so highly valorised in the unconscious, creeps more or less unnoticed into the thinking of pre-scientific chemistry.

Bygone methods for the cementation of steel were obviously dependent on a more or less mystical *cibation*. Under the heading 'Tempering' in the *Encyclopédie* we find this passage in which rationalisation does not prevent us from seeing traces of the primitive idea of food:

> Making steel means loading the iron with as much phlogiston or inflammable parts that it can contain. In order to produce this effect, we add to the iron that we wish to turn into steel all kinds of fatty substances, which contain a great quantity of the inflammable principle that they impart to the iron ... It is according to this principle that substances from the animal kingdom are employed, such as bones, tough meat, birds' feet, leather, fur, etc.

Close to the hearth where iron ore is being worked some primitive peoples will, with magic in mind, place a casket full of feathers and fur. The pre-scientific metallurgist is more of a materialist and throws the feathers and fur into the crucible. In the same way, the technique of *tempering with garlic juice* corresponds if not to a myth of digestion at least to a *myth of seasoning* that acts like a causality of the very small. The following method of *tempering* to produce fine steel is set out in the *Encyclopédie*: 'Garlic is chopped into small pieces; brandy is then poured over them, and they are left digesting for twenty-four hours in a warm place; at the end of this time, it is all strained through a cloth and the liquor is preserved in a tightly corked bottle, so that it can be used when required in order to temper the most delicate of tools'. Diderot, a cutler's son, did not react against this method and passed this section for publication. You do not criticise your forefathers' techniques.

It is of course in alchemy especially that the myth of digestion is much used. It is therefore not surprising to see the many metaphors to do with digestion here. Thus, to quote Poleman, 'Ordinary corrosives, famished as they are, seek to devour metals in order to assuage their hunger and furiously attack them'. Antimony is 'a devouring wolf', and there are many engravings that depict it like this. As Le Pelletier says, 'this crystalline salt will, like a famished child, eat up and in a short time transform into its own nature any essential oil you may wish to give it'. And he describes the whole operation in terms of nutrition: 'In the same way, the alkalis and rectified spirits must come together in such a way that the one seems to have eaten the other'. The number of these images, which a scientific mind regards at the very least as futile, makes it pretty clear that for the pre-scientific mind they have a sufficient explanatory role.

III

Having linked together first the stomach and the retort and then biological and chemical phenomena as a whole and made them one, we shall now carry the analogy to extremes. In some pre-scientific cosmogonies, the earth is taken to be a vast digestive system. Whereas previously, a rather vague life of the earth had been evoked, it is now a precise kind of life that is in question. De la Chambre puts it simply: for plants, food has 'no organ for its coction[8] other than the earth, which acts as a stomach for it'. He also notes that 'Zoophytes have no stomach other than the earth'. Thus, all animals have a stomach: 'for some, this is internal and part of their bodies but for others it is not'. Other writers are more prolix however. For Hunault, the

three digestions that develop in either earth, kitchen, or stomach belong together:

> The mineral matter from which plants and fruits are produced is therefore first prepared in the earth which, like a stomach helped by the sun's heat, cooks and digests it. Cooks take over from it and, so to speak, place themselves between the earth and our stomachs. Through the skills of their industrious *digestions*, *triturations*, *macerations*, *fermentations*, *elixations*, *frying*, *torrefactions*, and all their other seasonings, they add to it what the ripeness of the fruits lacked ... The stomach is then placed between the cooks and the veins so that it may, through its leaven, exalt the quintessence of these substances, by which I mean this alimentary mercury, or this moist radical, of which the nourishment of the parts is made. Lastly, the fermentation of the veins comes between digestion by the stomach and assimilation by the humours, or their conversion into the substance of the parts.[9]

There is no doubt that what we have here is a *Weltanschauung* that would immediately disintegrate if the myth of digestion were to lose its clarity.

The same *excess* can be seen in Hecquet. It is not enough for him that stomachal digestion should take place by means of trituration: he wishes to show that the whole universe triturates and digests. An entire chapter of his book on digestion is devoted to showing that 'grinding has a large part to play in the digestions taking place in plants and minerals'. Nodes in the stem are, he says, 'so many presses or small hearts', and 'the air beats and works everything it touches ... chemists call it the earth's *fleece*'. And as we see, nothing puts a stop to the pedant's reverie: 'The moon especially and the stars, those great masses that turn on their centre, all of them together weigh down upon the air, trample and work it, refine and grind it'. The moon pushes on the air; air pushes on water; water, being incompressible, determines pressures in the bowels of the earth and makes *mineral digestions* easier. 'The grinding action may seem more difficult to conceive in the digestions taking place in minerals', he says, 'but these digestions are vegetations and it has just been seen that vegetations take place by means of grinding. Why indeed should we look for differences in how nature goes about productions of the same kind?' Hecquet recalls the theory of terrestrial veins and adds that 'Nature therefore seems to have copied the earth from the human body'. Thus, scarcely two centuries ago, the scientific community tolerated such outrageous inversions.

Moreover, in some texts we can observe the linking of very precise images and the most secret kinds of animist inspiration. For an author presenting a paper to the *Académie* in 1742, 'the earth's filters and strainers are its bowels and viscera. I would even say that they are its liver, spleen, and lungs, and the other parts destined to prepare the alimentary juices. It also has its bones, like a very regularly shaped skeleton'. If we do not adopt an ironic attitude when we read a text like this, but instead succumb for just a moment to its child-like charms and let ourselves be somehow drawn to it, we soon sense the vague idea forming once again behind all this misplaced precision. This vague, powerful idea is that of the nourishing earth, of mother earth, the first and last refuge of abandoned humans. We therefore have a better understanding of the psychoanalytical themes Otto Rank developed in *The Trauma of Birth*.[10] And we are also able to give a completely new meaning to the need felt by aching, frightened beings to find life – their life – everywhere, and to merge themselves, as eloquent philosophers say, into the Great Whole. Mystery and life do indeed lie at the centre; everything that is hidden lies deep, everything that lies deep is living and vital; the formative spirit – the formative mind – is 'subterranean'. This author goes on to say that 'In the Earth as in our bodies ... while everything outside is just decoration, or at the very most operations of little weight, within it are pursued those works that are the most difficult and the most important'.

In 1766, Robinet is still writing that 'A liquid circulates within our globe. It is laden with earthy, oily, sulphurous parts, which it carries to mines and quarries so as to feed them and hasten their growth. These substances are in fact converted into marble, lead, and silver just as food in an animal's stomach is changed into its own flesh'. We could find the elements of an unconscious theory of the universe that is based on bulimia's firm convictions. Gluttony is an application of the principle of identity. Everything can be eaten. And vice versa, everything is eaten. Robinet continues: 'Things all serve as food for one another ... Nature's conservation is at its own expense. One half of the whole consumes the other, and is in turn consumed by it'. This mutual consuming is difficult to rationalise and even difficult to imagine. For one who is digesting, it is on the contrary very easy to dream.

When we come to study the myth of telluric generation – a far more powerful and seductive myth than that of digestion – we shall have the opportunity of developing and emphasising these remarks by giving them their full psychoanalytical interpretation.

IV

The importance given to excrement is obviously linked to the myth of digestion. Many psychoanalysts have described the anal phase in children's psychic development. In *Capitalisme et sexualité*, R. and Y. Allendy remind us that 'Freud in 1908, Jones in 1921, and Abraham in 1921 have made lengthy studies of the *anal character* that the widespread accentuation of this digestive phase comes to have in adults' (47). A very lucid study of this can be found in their book. Reading this, one feels the need to couple classical psychoanalysis with a psychoanalysis of the feeling of having which is, as we have shown, originally digestive in essence. We cannot enlarge on this subject here. We simply wish to note that *objective knowledge with scientific pretensions* is itself encumbered with valorisations that are just as absurd.

It is scarcely credible that the eighteenth century should have kept in its pharmacopoeia remedies such as millefleurs and album graecum. Millefleurs – water of a thousand flowers – is nothing other than the product of distilling cow dung. Malouin devotes a short chapter to it in his *Chimie médicinale* of 1755. Let it not be thought that by cleansing the medicament, this distilling excuses the doctor. Urine itself is prescribed under the name of millefleurs. Malouin writes that:

> The urine chosen is that of a heifer or of a healthy young brown cow, fed on good pasture; it is taken in May or September, in the morning ... and carried warm to the sick person who must be fasting ... it is a foamy liquor, effective in dissolving obstructions formed by the thickness of the bile or by the viscosity of the other humours; it purges abundantly and even sometimes makes the patient vomit.

Malouin recommends it for asthma, dropsy, and migraine. He also observes that 'fresh dung from a cow fed on grass has the property of calming the inflammation of sores and tumours ... Since the male is different in temperament from the female, it cannot be denied that their dung is in some way different ... That of the ox is particularly useful in keeping a loose womb in place'. Let us note in passing the sexual over-determination that is presented here as an obvious principle. And in this anchoring of the womb by a malodorous substance let us also note the same kind of rationalisation that we have already pointed out, following Ernest Jones here. It is noteworthy too that Malouin does not offer any criticism. There is the same absence of criticism in Geoffroy's *Materia Medica*, which recommends the droppings of the rat *Stercus nigrum* as a cure for constipation. Externally, they cure the itch,

he says, and mixed with honey and onion juice they restore the hair and make it grow.

Album graecum is dog dirt. The *Encyclopédie* speaks of it in the following terms: 'Several writers, Ettmuller among them, have ascribed many properties to album graecum; they have celebrated it as being sudorific, attenuant, febrifuge, vulnerary, emollient, hydragogue, and specific in scrofula, quinsy, and all diseases of the throat'. The more despicable the substance may seem, the more exaggerated is the multivalent valorisation that we see here. The writer of this section shows a certain disaffection for this practice. 'We hardly use it now', he says, 'except in (the diseases of the throat) where it is used in a small or large dose, in an appropriate gargle'. This restriction in the formerly very widespread use of album graecum makes for a *rationalisation* that should give us the measure of how much an epistemological obstacle resists. It is believed that there is no way of overcoming the obstacle other than by belittling or eluding it. It is not felt that the obstacle lies in the mind itself. A remnant of value continues to be given to the false ideas valorised by the unconscious. Thus, the writer develops the following 'rationalisation':

> Album graecum is but animal earth, in fact, and it is consequently absorbent and analogous to prepared ivory, to philosophically prepared stag horn, etc. The dog's digestive humours and the water used in the lotions of this excrement in its preparation have exhausted the bones the dog chewed and swallowed, or have dissolved their lymphatic substance in more or less the same way that boiling water has exhausted stag horn in its philosophical preparation. It cannot therefore be seen to have an advantage over other absorbent substances belonging to the same class.

Once again, this timid, incomplete devalorisation is a pretty clear indication of the original *value* this strange medicament had.

Faeces have been the subject of many distillations. To quote Macquer, 'The procedure by which Homberg came to draw a white, odourless oil from faeces is a curious one and merits inclusion here because of the views and matters for reflection it can furnish'. Macquer does not really tell us what these views and reflections are but we can guess them if we are ready to bring in the need for valorisation. Indeed, we learn that distillation has got rid of 'the bad smell, now changed into just a stale one ... Homberg saw the cosmetic value of this water and gave some of it to a few people, the skin of whose faces, necks, and arms was in a very poor condition, being grey, dry, granular, and rough. They washed with it once a day, and the continued use

of this water considerably softened and whitened their skin'. In Geoffroy's *Suite de la Matière médicale* we find an even more detailed and therefore more incredible account, which would require detailed psychoanalysis, a psychoanalysis that is moreover easy to do. Geoffroy denies neither efficacy nor repugnance here. 'We are persuaded', he writes, 'that this liquor, which is soft and unctuous, can in fact soften and beautify the skin. Is it not extravagant though to be such a slave to beauty that one wishes to preserve it by using a thing so dirty and disgusting?'

Only a deeply disturbed unconscious can advise the use of such things. If we are to understand this kind of disturbance, we must consider not just the *readers* of such nonsensical ideas but the person who *first* tried them out. How can someone like Homberg or the lady to whom Geoffroy refers get the idea of looking for a cosmetic here? This can only be because of antithetical valorisation. People are unwilling to believe that the bad smell of a *natural* product should be fundamental to it. They wish to give an objective value to the fact that they have overcome personal repugnance. They wish to admire and be admired. All this results in a value being given even to anti-values. Hecquet had already responded to writers who sought to explain digestion by some kind of putrefaction, saying that 'This is a strange idea of such a fine operation that is so full of art and wonder'. The juices produced by digestion are in fact 'perfect, gentle, and kindly', and 'it would be ill-fitting for the nourishing juices were they to become malodorous'. Digestion is hard to explain – 'sure proof of the majesty of nature' – but for the pre-scientific mind it can only be explained in the realm of values. Such an explanation ceases to be open to contradiction. And love is deep when contradictory qualities are loved.

NOTES

1 Coenaesthesia is the general sense of existence arising from the sum of bodily impressions.

2 Bachelard's footnote: de La Chambre, *Nouvelles Conjectures sur la digestion* (Paris: 1636).

3 Bachelard is referring here to Bergson's conception of the intellect as 'relative to the needs of action', its aim being to 'fabricate', to make; for Bergson, the intellect develops as it acts on and handles solids, and is only at ease when doing so (see *L'Évolution créatrice /Creative Evolution*, Introduction and Chapter 2). Bachelard regards such a view as untenable in the light of modern science, where in microphysics for instance the intellect clearly does not handle solids, and he constantly argues against it.

4 'Those with a fever are thirsty, those getting better are hungry'.

5 Bachelard's footnote: A. Roy Desjoncades, Doctor of Medicine, *Les Loix de la nature, applicables aux loix physiques de la Médecine, et au bien général de l'humanité*, 2 vols. (Paris: 1788).

6 Bachelard's footnote: Anonymous, *Nouveau Traité de Physique sur toute la nature* (Paris: 1742). For the full title of this work, see Chapter 6, note 29. Bachelard does not give the source of his previous quotation from de La Tourette.

7 Bachelard gives the source in note form in his text as the article entitled 'Digester' in the *Encyclopédie*.

8 Coction means both digestion and cooking; the first meaning of the Latin root word *coctio* was digestion, the sense of 'cooking' being added later.

9 Bachelard's footnote: Hunault, *Discours physique sur les fièvres qui ont régné les années dernières* (Paris: 1696).

10 This was first published in German in 1924.

Chapter Ten

The libido and objective knowledge

I

The myth of digestion is pretty lack-lustre when compared with the myth of generation; *having* and *being* are nothing in comparison with *becoming*. Energetic souls want to *have* in order to *become*. Classical psychoanalysis was therefore quite right to stress the supremacy of the *libido* over appetite. Though appetite is sharper, the libido is more powerful. Appetite is immediate; the libido is on the contrary endowed with patience, thinking slowly and carefully and forming projects for the long-term future. A lover can be as patient as a scientist. Appetite subsides on a full stomach. But no sooner has the libido been satisfied than it springs to life once more. The libido *wants* and *is* duration. It is attached to everything in us that *has duration*, either directly or indirectly. It is the very principle of the valorisation of time. Gratuitous time, time that has been emptied, the time of a philosophy of repose, is time that has been psychoanalysed. We shall be working on this in another book.[1] Let us simply remember that patience is an ambiguous quality, even when it has an objective aim. Psychoanalysts will have more work than they had bargained for if they extend their research into the realm of intellectual life.

Indeed, classical psychoanalysis has been concerned above all with inter-psychology, that is to say with individual psychological reactions that are determined by social and family life, and it has not turned its attention to objective knowledge. It has not seen what is special about human beings who leave their fellows for objects, about those super-Nietzscheans who, climbing a higher mountain, also leave their eagles and serpents and go off to live among the stones. Yet what a strange destiny this is, and stranger still in the century we are living in! Our whole culture is being 'psychologised' and interest in the *human* pervades both press and novels, where there is no re-

quirement other than that of an *original* story, certain of finding a devoted daily readership. Remarkably, we can at such a time still come across souls who are thinking about sulphates! This return to thinking amid stones is no doubt in *psychologists'* eyes the regression of a life that is becoming mineralised. Being and becoming are their province, as also are human beings, filled as they are with the future and with mystery! There is a long book waiting to be written about this devalorisation of objective and rational life which, from the outside, declares science to be bankrupt, never itself participating in scientific thought. Our task is a more modest one. We must make the resistance of epistemological obstacles clear in the very detail of objective research. It is here that we shall see the influence of the libido, a libido that is all the more insidious for having been put aside earlier on and also for the fact that in scientific tasks repression is both easier and more necessary. The scientific realm is one of intentional aridity, where of course the outcropping of the libido is often scarcely apparent. We therefore crave our readers' indulgence, aware as they must be of the difficulty of a task that in the end aspires to analyse the sensitivity of hearts of stone.

Here then is the plan of this complex chapter. In developing this psychology of the scientific unconscious, we shall begin with the vague and work towards the precise. Indeed, what is vaguest is what is most powerful where the libido is concerned. The precise is already an exorcism. All intellectualisation, even when it still bears the undeniable mark of affectivity, is already a discharging of that affectivity. We shall find good ground in alchemy for the study of vague sexuality, and telluric generation will show us vast sexuality. As for precise sexuality, we shall find many examples of this in the eighteenth-century pharmacopoeia and also in the electrical researches of the same period. Lastly, we shall follow our practice in this book of illustrating the great epistemological obstacles by particular examples: thus, for the obstacle constituted by a general image, we studied the phenomena associated with the sponge; for the substantialist obstacle, we studied gold, which provided us with a pretext for psychoanalysing realists. As regards the obstacle constituted by the libido, we shall make our observations both concrete and precise by studying the idea of *germ* and *seed*. We shall then see what constitutes a *privileged becoming*, that is to say a substantified becoming. We shall end by giving readers a few pages to be psychoanalysed, just as a little exercise.

II

We cannot think for long about a mystery, a puzzle, or some fanciful

enterprise without more or less silently sexualising both its principle and its vicissitudes. This is doubtless because the first mystery for the child was the problem of birth. The secret of generation that parents know and conceal – in their bungling, ironic, or malevolent way, with either smiles or cross words – establishes them as arbitrary intellectual authorities. Because of this, parents are from then on seen by their children as teachers who do not say everything there is to say. Children therefore have to start searching all on their own. And all on their own, they recognise the *absurdity* of the first explanations offered. They quickly become aware that this absurdity is intellectual malevolence, and proof that there is a desire to hold intellectual dominion over them; this leads to an awakening of the mind, which moves along paths that were meant to be forbidden ones. A converse is soon established in the mind that is being formed. Since the libido is mysterious, everything that is mysterious awakens the libido. There is an immediate love of mystery, an immediate need for mystery. Many cultures are rendered childlike or puerile because of this and lose the need to understand. For a long time, if not forever, reading has called for mysterious themes; it needs to keep a great unknown well ahead of those reading. It also needs this mystery to be a human one. Lastly, culture as a whole is being 'fictionalised'. The pre-scientific mind is itself affected by this. A rather dubious kind of popularisation tends to surround precise laws with a fringe of indefinite and mysterious properties, which it constantly maintains. It courts the need for mystery, whose impure source we see. This kind of popularisation is, in the end, an obstacle to the development of abstract thought.

Alchemists treat new adepts in the same way that we treat our children. At the beginning of the initiation process, provisional and fragmentary absurdities serve as reasons. These absurdities work by means of symbols. Alchemical symbols may well come to be regarded as a system but they are still simply coherent absurdities. They therefore help to shift the mystery, which to all intents and purposes means playing with mystery. Lastly, alchemy's secret is a convergence of mysteries: gold and life, having and becoming, all are brought together in the same retort.

However, as we have already pointed out here, the lengthy operations performed in order to attain the philosopher's stone also valorise this quest. The long heating process is often presented as a *sacrifice* made so as to deserve success. It is valorised patience, a kind of intricate embroidery that is both useless and charming, like Penelope's tapestry. Time must be inscribed in the work of alchemy, hence the durations allowed and the set pattern of repetition. If adepts undergoing initiation remember their past, they must tell themselves that of all life's mysteries, only the first mystery of birth has been

as resistant as the mystery of the work of alchemy.

Here, we see solitude becoming a bad counsellor. A solitude as unyielding as that of someone keeping watch over alchemy's furnaces is ill-protected against sexual temptation. In some respects, alchemy could be said to be the secret vice. Psychoanalysts will easily discern onanism in certain pages of the treatise entitled *Le Triomphe hermétique ou la pierre philosophale victorieuse*.[2] The *Stone* boasts in fact of its superiority over the simple union of male gold and female mercury, in the following terms: 'It (the stone) marries itself; it makes itself pregnant; it is born of itself; it is dissolved of itself into its own blood, it is coagulated anew with it, and takes a hard consistency; it makes itself white; of itself, it makes itself red'. It matters little for our interpretation that modern chemists find an objective meaning, an experimental meaning, in the marriage of stone with itself. The fact remains that the symbolism here is symptomatic.

For centuries, certain alchemists often repeated that an animal's sperm could not serve to form a metal. This statement is especially surprising given that primitive mentality could easily accept plants turning into people, statues coming to life, and a human being changed into a block of salt. An anonymous author[3] advises against blood and human sperm being used in the work of alchemy. But why was it necessary to advise against this?

In some books, the Stone shows a real power complex, illustrated by the following quotation in which it speaks: 'Had the artists[4] taken their researches further and given full consideration to the wife most fit for me; had they sought her and united me with her; then could I have tincted a thousand times more. But instead of that they have wholly destroyed my own nature, by mixing me with strange things'. This, as we see, is the lament of the mismarried. It can be fairly easily imagined as coming from a scientist who leaves his home for the laboratory, seeking from the 'beauty of science' the delights forbidden him by his ill-favoured wife. It provides moreover a valid way of explaining Balzac's *La Recherche de l'Absolu*.

When Eudoxe explains this passage, there is an accumulation of all the metaphors of the dream wife: the wife fit for the Stone is 'that fount of living water, whose truly celestial spring, which in particular has its centre in the sun and moon, produces this clear, precious stream that sages know ... She is a celestial Nymph, a chaste Diana, whose purity and virginity are unsullied by the spiritual bond uniting her with the stone'. This marriage of heaven and earth constantly recurs, sometimes in a vague way and sometimes more precisely.

Many alchemical operations are referred to by the term of divers incests. It is quite obvious that the mercury of the alchemists suffers from the Oedipus complex. We learn that 'It is older than its mother, who is water, because it is more advanced in the age of perfection. For this reason it is feigned as Hercules, because it kills monsters, vanquishing strange things, things far from the metal. It reconciles its father and mother, banishing their old enmity; it cuts off the King's head ... so that it may have his kingdom'.[5]

Elsewhere, the same complex can be seen even more clearly, as for instance in this verse:

> I, a father before a son, engendered my mother
> And my mother carried me, fatherless, in her womb
> Without having need of any nourishment.
> A hermaphrodite I am of one and the other nature
> The strongest's vanquisher, and mastered by the feeblest
> And nothing there is beneath the vault of Heaven
> So fair, so fine, and of such perfect figure.

The castration theme can be seen in other texts. The following extract is just one example of this:

> Mercury is sterile. The Ancients accused it of sterility because of its coldness and dampness; but when it is purged and correctly prepared, and heated by its sulphur, it loses its sterility ... The mercury of Abraham the Jew, the feet of which the Old Man wishes to cut off with his scythe, is the fixing of the mercury of the Sages (which is by its nature volatile) by the perfect elixir, whether red or white; thus, cutting off Mercury's feet means taking away from it its volatility; this elixir can only be made over time, which is represented for us by the Old Man.[6]

If we study the engravings that often accompany a text like this, there can hardly be any doubt about the psychoanalytical interpretation we are proposing here. The alchemists' way of thinking is directly related to dreams and daydreams: it merges together objective images and subjective desires.

We could on many grounds also ascribe shameful moral standards to mercury. The dialogue between the Alchemist and the Mercury in the Cosmopolite's book could have been written by Plautus, for it is like a master reprimanding a dishonest slave: 'Evil rascal, gallows-bird, traitor, rogue, boor, devil, demon!' He staves it off as one would a serpent: Shoo, shoo, foul bone and dunghill! We need only go back to the first scene in Act One of Plautus's *Amphytrion* to measure the full significance of the alchemists' animism. Sometimes the mercury complains: 'My body is so lashed, so ransacked, and

so covered in spit that even a stone would take pity on me'. The relation between alchemist and mercury could often be called that of a jealous husband beating and questioning his wife. Moreover, when an experiment fails, the alchemist 'beats his wife'. This expression is a fairly frequent one. It is highly ambiguous: does this scene take place in the laboratory or in the bedchamber?

Fairly frequent too is the claim to be hermaphrodite, this characteristic being held superior.[7] The Stone boasts of possessing seed that is both masculine and feminine: 'This sulphurous fire is the spiritual seed that the Virgin, even while keeping her virginity, never ceased to receive ... it is this sulphur that makes our mercury Hermaphrodite'.[8]

When the sexual contradiction opposing male and female has been surmounted, all other contradictions are consequently overcome. Contrary qualities then accumulate about the same substance and we have complete *valorisations*. For de Locques in *Les Rudiments*, mercury is a substance:

> that does not wet the hands, very cold to the touch although very hot within, a water of life and of death, a water that flows and is frozen, very damp and very dry, white and very black and of every colour, with no smell and nevertheless with all the smells in the world ... very heavy and very light in movement, metallic and fulgid like talc and pearls; green like an emerald, that beneath this greenness contains the whiteness of snow and the redness of poppies.

It is in short a diverse and changing being, a human heart with all its passions.

For psychoanalysts, these texts – and it would be easy to quote from many more – are clear indications of moral turpitude. The fact that we are putting them together in a systematic way may well be found surprising. Readers will in particular remind us that in an earlier chapter here, we worked out an anagogic interpretation of alchemy in which we undertook to prove alchemy to be a high moral culture. We could therefore be accused of being contradictory. However, this accusation means that alchemy's development in the realm of values is being forgotten. It is because impure tendencies are evident that the need for purity or purification is advocated in so many texts. The reviling of impure alchemists is a measure of the temptations they undergo. Alchemical books are as much moral as scientific texts. Their purpose is to preserve from wrongdoing as much as from mistakes. In no modern scientific book would we find passages like the following, in which Poleman writes against impure alchemists: 'How then could divine wisdom remain in such a pigsty, full of mud and filth, adorning it with its gifts and impressing

its images there? Everywhere, their inside and their outside offer but the abominable images of the Peacock's pride, the pig's miserliness, and other vices of dogs and oxen, with which they are coated and encrusted'. Let us note in passing that if the pig is said to be miserly, this is because it is greedy: greediness is indeed then the animist form of taking possession, as we argued in our previous chapter on the myth of digestion.

While the moral lesson is often calmer, it figures in most texts. It is deeply influenced by conceptions of the natural good, of the good that is bound up with nature. For example, the Cosmopolite writes that 'The Investigators of Nature must be such as Nature is itself; that is to say, true, simple, patient, constant, etc., and what is principal, pious, God-fearing, and causing no harm to their neighbours'. Thus alchemy is involved, more than modern science is, in a system of moral values. It is alchemists' souls that are engaged in the work of alchemy, the *object* of their meditations receiving every value. One who handles the skimmer must indeed have a moral ideal. By their art, alchemists must separate 'the stains and filth of the three general principles; furnishing them with a matter, a place, or a vessel more fit than is that in which nature operates, which is full of dirt and a myriad kinds of foulness'.[9] Their art takes away 'the dirt and grossest parts from the salt, the superfluous aquosities from the mercury, and the adustive parts from sulphur'. This purification is, as we see, performed with more of a moral than a scientific ideal. Its tone is not that of the purification of substances in modern chemistry. It despises what it rejects. Those handling the skimmer do so with an expression of disgust on their faces.

III

Normal sexuality is of course the subject of countless references in alchemical books. To see this, we need only read the Cosmopolite's fifth chapter, entitled 'Of the marriage of the red servant with the white woman'. We shall limit ourselves however to just a few examples of this here, since many studies of this topic have been made.

Alchemical operations are often described as more or less closely observed copulations. Thus, an anonymous author writes that 'When you have seen the natures merge together in the glass vessel and become like coagulated, burned blood, you may be sure that the female has suffered the embraces of the male ... and therefore that the Royal Child has been conceived'.[10] He writes too that 'It is this gold, that in our work takes the male's place and that is joined with another gold, one white and crude, which takes the place of female seed, in which the male places his sperm: they unite together in an

indissoluble bond'. Writing in 1758 in his *Dictionnaire mytho-hermétique*, Dom Pernety has this to say about the word marriage: 'Nothing is more current in the writings of Philosophers[11] than this term. They say that the Sun must be married with the Moon, Gabertin with Beya, mother with son, brother with sister; and all this is nothing other than the union of the fixed and the volatile, which must take place in the vessel by means of fire'. The Cosmopolite wishes 'that we should know how to marry things together according to Nature, for fear of uniting wood in marriage with man, or an ox or some other beast with metal; but on the contrary, that like should act on like, for then Nature will not fail to do its duty'. He also sets out to command nature by obeying it, but his obedience is almost feminine, and a kind of seduction. 'Look', he says, 'at that in and by which Nature is improved ... If you wish, for example, to extend the intrinsic Virtue of each metal ... you must take metallic Nature, and this indeed in the male and female, otherwise you will do nothing'. In short, do not rush things but keep an eye on sexual affinities. De Locques, a writer who is more of a doctor than an alchemist, also states that 'The diseases of metals that stem from their forms or their metallic spirits are twofold, coming from either the difference of their sexes or the contrariety of their forms'. For him, sulphuric metals are masculine, mercurial metals being feminine. For another writer, there are two kinds of rubies, the male and the female. Naturally, 'the males are the most beautiful and are those that shine most brightly; the females are those that glow less'. Much more recently Robinet, after a moment's hesitation, still hopes to discover mineral sexuality. Writing in 1766, he says this: 'As for the distinction between the sexes that has not yet been acknowledged in metals, we have sufficient examples proving that it is not absolutely necessary for generation; and in particular, fossils could regenerate from their broken, splintered, and sundered parts. However, we must not despair of one day managing to distinguish between male and female gold, and between male and female diamonds'. Thus, the sexualisation active in the unconscious seeks to distinguish in the same metal, in an amorphous body such as gold, if not sexual organs then at least different sexual powers. When a mineral presents forms or features, then naturally the dreaming unconscious clearly projects its desires. This is a well known habit with some obsessive characters. Robinet artlessly conveys the tenor of his daydreams:

> In closely considering stones with forms and features, and with grooves, spikes, and stippling, I felt myself led to believe the little rises of some and the cavities of others to be so many spermatic pods ... Many empty capsules will be found; in this case, I invite the curious to examine with a magnifying-glass the little stony shards that formed the pod; they will see them to be pierced with small holes through which the seed has been ejaculated.

As we can see, Robinet's objective knowledge would have gained from undergoing a preliminary psychoanalysis.

IV

Yet the libido does not always need such precise images, and it can be content to *interiorise* powers that are more or less mysterious. In this interiorisation, substantialist and animist intuitions are reinforced. Substance that is enriched with seed secures its own becoming. We read that 'Even though it is an extremely perfect and digested body, our gold is however reincruded in our Mercury, in which it finds a multiplying seed, that fortifies its weight less than it does its virtue and its power'.

More strikingly, for alchemists *every interior is a belly*, a belly that must be opened up. An anonymous author writes as follows: 'Open up your mother's breast with a steel blade, go deep into her entrails, and penetrate even her womb; it is there that you will find our pure matter, that does not yet have any tincture taken from the bad temperament of its nurse'.[12] The anatomy of this mysterious mineral that 'has the same volume as gold' is sometimes accompanied by a seducer's language: 'Open then her entrails with a steel blade and use a gentle tongue, insinuative, pleasing and caressing, moist and ardent. By this artifice you will make manifest that which is hidden and concealed'. We see that alchemists, like all philosophers who valorise, look for the synthesis of contraries: by steel and tongue, by water and fire, by violence and persuasion, they will reach their goal. Pierre-Jean Fabre says that alchemy does not just study metals but: 'even these four vast bodies we call the four Elements, which are the pillars of the world, cannot by their size and great strength prevent Alchemy from penetrating them through and through, and from seeing by means of these operations what they have in their bellies and what they have lying hidden in the farthest part of their unknown centres'. Before experience, there is for the dreaming unconscious no placid, tranquil, cold *interior*. Everything that is hidden germinates. To quote the anonymous writer of the *Triomphe hermétique*, 'The source of the sages' liquor... lies hidden under stone; strike it with the rod of magic fire and from it will come a clear spring of water'. From the interior, the contrary comes. The interior must magnify the exterior. This at least is what dreams would wish. And so when the consciousness gives the lie to the unconscious, when all experiments and experiences have been assayed, and all books read, how

sad the flesh is![13] The disillusionment of the child whom the inside of a toy Punch always disappoints is equalled only by that of a lover when he knows his mistress.

V

Some alchemical books have a very symptomatic characteristic that must be noted: this is the frequency of the dialogue form. This dialogue form is proof that thought is developing on the I-thou axis rather than on that of I-that, to use Martin Buber's language.[14] Thought is not moving towards objectivity but towards the person. On the I-thou axis, a myriad aspects of the personality are delineated; the interlocutor is then the projection of convictions that are less certain, putting a doubt, an entreaty, an unspoken desire into concrete form. Yet dialogue is often poor preparation for objective dialectics. The personalisation of tendencies leaves too deep a mark on the differentiations of reality. In other words, two interlocutors who are apparently conversing about a precise object tell us more about themselves than about this object.

Some alchemists suffer from real logorrhoea and this must be noted, bearing as it does the same mark of thought that is spoken, confided, and whispered. It has often been pointed out in fact that alchemists would give the same principle very many and very different names. The psychological meaning of all this verbal multiplication does not however seem to have been seen. It has been interpreted as just a way of keeping mysteries and secrets for themselves. Yet mystery would have been sufficiently preserved by the vast number of cabalistic names in use. In our view, sexual modesty, not mystery, is the explanation. It results in the need to counterbalance one gender by another. Thus, mytho-hermetic *matter* is sometimes called woman and sometimes man. It is Adam and it is Eve. A modern mind is not good at measuring these variations. For example, we are utterly confused when we read through the list of names given by hermetic philosophers to their *matter*. For this 'matter of all matter', this 'stone that is not stone', this 'mother of gold', this 'sperm that is not stone', I have counted 602 names and it is likely that I missed some of them. These 602 names for one and the same object are surely enough to show that this 'object' is an illusion. It takes both time and love to heap such eloquent adoration upon a single being. It is night when alchemists dream beside their furnaces, when the object is still only a desire and a hope, and when metaphors gather together. Thus, a mother showers a myriad names on the child she is cradling. Only lovers could give six hundred names to the beloved. And in the same way, only lovers could bring so

much narcissism to their protestations of love. My gold is more than gold, my mercury is more than quicksilver, my stone is more than stone: these are the words that alchemists continually repeat, in the same way that lovers claim their love to be the greatest that ever dwelt human hearts.

It may be objected that this logorrhoea flows over an object without defining it, and some may remind us of precise experiments that can be recognised under these verbal adornments. This is how historians of chemistry systematically proceed. It appears to them that a realist, positive, and empirical interpretation gives undeniable solidity to some of alchemical knowledge. On the other hand, it seems that literature has accustomed us to gratuitous images, to short-lived images, to images which do not attach themselves to things but simply express their fleeting aspects. Speaking personally, our own position is an intermediate one, coming between that of historians and poets: while we are less certain of the *realist basis* of alchemical experiments than historians are, we are also more realist than the poets, provided that reality is sought in psychological concreteness.

Indeed, in our view, metaphors always bear the stamp of the unconscious; they are dreams whose occasional cause is an object. Consequently, when the metaphorical sign is in fact the sign of sexual desires, we believe that words must be interpreted in their fullest sense and given their full weight, as an outpouring of the libido. In our view, if we go deep into the soul and relive the experience of humankind at work, at long, slow work that comes easily once mastered, living once more with hands moving in well-ordered effort, we must remember that human thought then dreamed, that the human voice expressed in song the hands' caresses. In monotonous work – and all work informed by knowledge is monotonous – homo faber is not doing geometry but instead writing poetry. In our view, when in former times vine-growers married the vine to the elm, they were congratulated by the satyrs.

This is d'Annunzio's song:

Viva dell'olmo
E della vite
L'almo fecondo
Sostenitor![15]

VI

It will also be said that all metaphors are worn-out and that the modern mind has, by virtue of these metaphors' very mobility, overcome the emotional seductions that are no longer a hindrance to our knowledge of objects.

Yet if you were to examine what is going on in a mind that is being formed and that is confronted with a new experience, you would be surprised to find at the outset sexual thoughts there. It is thus very symptomatic that a chemical reaction in which two different bodies are involved is immediately sexualised, sometimes with little attenuation, by determining one of the bodies as active and the other as passive. As a chemistry teacher, I have been able to observe that in the reaction of an acid and a base, nearly all the pupils would give the active role to the acid and see the base as passive. If we go just a little into the unconscious, we soon see the base to be feminine and the acid masculine. The fact that the product is a neutral salt – a *neuter* – is not without some psychoanalytical resonance. Boerhaave still speaks of hermaphrodite salts. Views like this are real obstacles. Thus, the idea of basic salts is much harder to get young secondary-school pupils to accept than that of acid salts. Acid has been given the explanatory advantage simply because it has been taken as being active in respect to the base.

The following seventeenth-century text leads to the same conclusions:

> The acid ferments with the alkali because having once engaged its small point in one of the pores and having not yet lost its movement, it makes an attempt to thrust further forward. By this means it enlarges the parts, so that the little acid that is in the alkali, no longer finding itself so tightly constrained, joins with its liberator to throw off in unison the yoke that nature had laid upon it.

A scientific mind, whether rationalist or experimental by training, whether that of a geometrician or a chemist, will not find any element of reflection, any sensible question, or any descriptive schema in such a passage. It cannot even make a critique of it, such is the distance between figurative explanation and chemical experiment. A psychoanalyst, on the other hand, would have no difficulty in discerning the precise source of this conviction.

If we knew how to trigger confidences about the inner state of mind and spirit that accompanies the quest for objective knowledge, we would find many traces of this very sexual attraction to certain chemical phenomena. Thus in his journal, Jules Renard transcribes the following reverie, which is quite obviously linked to schoolboy memories:

> The love of two metals is the stuff of romance. They were first seen as inert and cold in the hands of the teacher-matchmaker; then, as the fire took action, they were seen to merge, to penetrate one another, and to become identified in an absolute fusion of a kind that the most passionate love will never achieve. One of them was already yielding, liquefying in one extremity, and resolving into spluttering, whitish drops.

Passages like this are very clear to psychoanalysts. They are much less clear though for a realist interpretation. It is very hard in fact to determine the *reality* that Jules Renard had seen. Forming alloys of *metals* is rarely part of the curriculum in the junior years of our secondary schools, and metals do not yield as easily as this, liquefying in one extremity. Here then objective interpretation is blocked off and what lies open to us is psychoanalytical interpretation. It is particularly piquant to see an ironist being so clumsy when it comes to concealing his schoolboy desires and habits.

VII

Yet the alchemist is not a schoolboy. He is not even a young man. Usually, the alchemist is the Old Man, the Old One. This is why the theme of rejuvenation is one of alchemy's dominant themes. Theories that see alchemy as money-grubbing lead, here as elsewhere, to the wrong interpretations being made. You will doubtless find alchemists who sell the water of youth and old, rich princes who buy it. But what is money in comparison with youth? It is the hope of growing young again that keeps them going in the long watches of the night, in the long hours at the furnace, and that makes light of a fortune lost, the hope of finding themselves in the morning with once again a gracious countenance and smouldering eyes. The perspective from which alchemy can be understood is that of the psychology of fifty-somethings, the psychology of a man who has just felt a first threat to sexual worth. Who will not spare any effort to drive this shadow away, to erase this ill omen, and defend what is supremely valued? It is by interpreting occupations in terms of preoccupations that we can understand their real, inward meaning. Once it has really been accepted that alchemists are always fifty-year-old men, then the subjective, psychoanalytical interpretations we are proposing here become very clear.

Alchemical substances must thus make time go backwards and they are therefore temporalised to a very high degree. When it is a matter of deciding the best time of year for 'alchemical nuptials', the alchemists hesitate between spring and autumn, between seed and fruit. They would like to be able to put the two seasons together, adding spring to autumn, youth to maturity, all in one elixir! This is exactly what the *philosophers' emerald* does. This water of youth is described in the *Dictionnaire hermétique* as 'the dew

of March and September, which is green and sparkling; the autumn dew is more baked than that of springtime, especially since it shares more of summer's sun than winter's cold. This is why those who use them refer to the autumn dew as male and to the spring dew as female'.

How few are the things and the reasons we need in order to uphold the principle of rejuvenation! The least occasional cause awakens in us the will to grow young again: fortified by this unspoken wish, we turn the objective pretext into an efficient cause. In 1669, Charas writes as follows in his treatise on vipers, a treatise that also shows great powers of observation: 'Vipers shed their skin every spring and sometimes even in autumn; this has led people to believe quite rightly that they possess a virtue that will renew and conserve the forces of those who use them as either a protective or a remedy'. Later in the same treatise, we read that:

> Again, a restorative virtue is rightly attributed to the viper ... which can rejuvenate, as it tacitly shows by shedding its skin twice a year and renewing itself, finding itself covered with a new skin. This, together with the subtle parts of which the viper is composed and its keen, intrepid gaze, shows that it is very appropriate that the Ancients ascribed to it the virtue of brightening and fortifying the eyes.

It is clear to us that the entire argument here amounts to *interiorising* and *multiplying* the phenomenon of sloughing, making of it a substantial and living virtue, which is attached not just to the whole being but to every one of its fibres and to all its matter. The unconscious that wants to grow young again could not ask for anything more.

VIII

However, animist power takes on its full *value* when conceived in universal terms, uniting heaven and earth. Earth is then presented not just as nourishing, as we have shown it to be in the myth of digestion, but also as a mother who engenders all beings. We shall bring together a number of texts from the pre-scientific period, which show how readily this argument gathers the least objective of reveries.

For Fabre:

> Everything works for the earth and the earth works for her children, like the mother she is of all things; it seems indeed that the general spirit of the world loves the earth above all other elements; accordingly, it comes down from highest Heaven wherein is its seat and royal throne, among its palaces of azure and gold, studded with an infinity of diamonds and carbuncles, to live in the deepest dungeons, in earth's most dark, damp caverns; there, it takes on the vilest and most scorned of all the bodies it can produce in the Universe, which is the salt of the basest part, the salt from which the Earth was formed.

Generation is thus the conciliation of both high and low values, of good and evil, and of love and sin. In other words, generation is the valorisation of lower, inferior substances. Fabre does not see metaphors here. What comes from on high is in fact matter that need only be gathered for us to have *universal medicine*. It has to be taken as it first springs up, at its birth and its origin, following the advice we might find coming from the pen of modern psychologists, as they extol new-sprung intuition, intuition that is being born. For seventeenth-century doctors though, that which *begins* is that which engenders; that which engenders is matter that realises power. This celestial matter, Fabre later states, 'must be taken the moment it comes down from Heaven and does but kiss, gently and lovingly, the lips of natural mixts and compounds, the moment when its maternal love for its children makes it shed tears brighter and more shining than pearls and topazes and which are but light, clothed and covered with damp night'. We see only too well the significance of this sexual materialism that gives a concrete form to springtime emotions, that gathers the morning dew as the essence of the marriage of heaven and earth.

The sea is also often considered to be a universal womb. Nicolas de Locques says that it forms 'a nourishing, aqueous dampness and a salty, spermatic, engendering substance'. Using an even more precise and symptomatic image, he goes on to say that 'Just as at the time when women conceive or their seed is corrupted, they see and feel their colour changing, their appetite diminished and their mood disturbed, so in the same way the Sea grows stormy and turbid in Tempests, when it produces this salt outside itself for the conception of the children it bears'.

The generating act is an idea that is as explanatory as it is obsessive; in other words despite carrying the full weight of unconscious folly, an idée fixe *is an idea that is clear*. The Cosmopolite writes thus: 'Just as man's sperm has its centre or proper receptacle in the kidneys, so in the same way the four Elements, in a tireless and perpetual movement ... cast their sperm into the centre of the Earth where it is digested and then by movement thrust outside'. He continues as follows:

> Just as a man casts his sperm into a woman's womb, in which no seed remains, and which having taken its due portion, casts what remains outside, so in the same way it happens that in the centre of the Earth the magnetic or attractive force of the part of some place draws to it that which is appropriate for engendering something, and then thrusts what remains outside, making of it stones and other excrements.

In all these examples the influence of valorisation can be seen, for there is a conflict between *opposite values*, good and bad, pure and impure, sweetness and decay. The guiding idea, therefore, is that generation issues from corruption. Alchemists, by their own account, seek their precious matter in the 'belly of corruption', just as miners seek it in the impure belly of the earth. Seeds must rot and putrefy in order for formative action to be produced within a mother's womb or within the womb of earth. This antithetical valorisation is highly symptomatic. It can be seen in themes other than generation. Thus, stench prepares perfume. Passing through blackness and stench proves to the Artist – the alchemist – that he is on the right path; evil smells underground prove to miners that they are close to the regions of the earth that are both putrefying and engendering.

Remedies that taste bad and have a bad smell are regarded as the best. What is bitter to our mouths is good for our bodies. It can be said that the whole of pre-scientific thought develops in the fundamental dialectic of Manichaeism.

IX

All this vague sexualism, which to a greater or lesser extent is wrapped up in traditional poetry, will be clearer however if we look at slightly more recent texts. In our view, it will be very instructive to consider eighteenth-century texts to do with electrical science. We shall then have confirmation of the idea that all *nascent* objective science goes through a *sexualist* phase. Since electricity is a *mysterious* principle, the question must be raised as to whether it is a *sexual* one. Hence the experiments done on eunuchs. *Sublata causa, tollitur effectus*.[16] This is the opinion expressed by the prudent van Swinden: 'Some maintain that lightning cannot be passed through a Eunuch and that the circle of an electric shock is broken if a Eunuch is a part of it. I can affirm that this does not happen with dogs or capons (van Swinden is referring here to a similar view expressed by Herbert) but I have not yet had occasion to perform similar experiments on men'. He then reminds us that experiments of this sort had been done by Sigaud de la Fond, an important

experimenter whose books enjoyed great fame:

> Sigaud de la Fond performed this experiment on three Musicians of the chapel of the King of France, about whose state there was no doubt. They felt the shock and did not stop it in any part of the chain, which was made up of twenty persons. They seemed even more sensitive to it than any of the others who felt it with them; yet it is very likely that this excess of sensitivity was simply due to their surprise.

Thus, even when the otiose hypothesis has been destroyed, there is still a desire to justify the influence of sexuality on electrical principles. Eunuchs are not insensitive to electric shocks as was postulated by the sexualised unconscious. This conclusion is then immediately inverted: they are therefore *more* sensitive than others. Sigaud de la Fond will look in vain for psychological reasons for this heightened sensitivity: eunuchs are prone to surprise, no doubt more impervious to warnings because they run no risk by letting themselves be electrified. Moreover, the atmosphere of this splendid experimental session can easily be imagined. The spectators approached the laboratory with questions suggested to them by the unconscious. There, they again repeated the *electric kiss*:[17] two 'experimenters' standing on an insulated stool closed the *chain* with their lips. The moment the Leyden jar was discharged, the electricity valorised their kiss by making it prickle and burn. Conversely, the kiss valorised electrical science.

Electricity has a less superficial power. The serious Abbé Bertholon is lavish with his technical advice. He reports that:

> Two married persons had not been able to have children for more than ten years, and electricity revived their hopes. As soon as they had knowledge of the effectiveness of the means I propose they arranged for their bed to be insulated. A connecting iron wire, which had been insulated, was passed through the dividing wall between their chamber and a neighbouring room in which the electrical machine was placed ... After some twelve or fifteen days of electrification, the woman conceived and later gave birth to a child who now enjoys good health: it is a fact that is famed far and wide ... Le Camus, of the *Académie de Lyon*, knew a young voluptuary who, with a view to his designs, had himself electrified by sparks in a particular manner, and who that evening had reason to be very satisfied with his endeavours. Bonnefoi tells us of a Wittemberg professor called Boze who, having been unable to have children in twenty years of marriage, had himself electrified along with his wife, with a very happy result. Mazars has several times

observed the triumph of electricity over a lack of virility.

Innumerable examples could of course be given of the use of electricity to cure venereal diseases, without of course any precise statistics having first justified this method. Electricity is very favourably considered. The more mysterious it is, the more sexualised it becomes. And it is because of its mystery that it can be sexually effective.

Jallabert, a much-quoted experimenter, associates substantialist and sexualist intuitions. In his opinion, if brilliant sparks can be drawn from animate bodies, this is because 'they abound in oily, sulphurous, and consequently inflammable parts'.[18] He reminds readers that 'the omentum and the blood and bile etc. have a considerable quantity of these in them ... urine that is distilled after it has fermented and divers other animal substances furnish very active phosphors'. Jallabert then finds an easy explanation for all this in that 'people of different ages and temperaments do not produce sparks of equal strength'. Taking his conjectures further by *realising*, in the full sense of the term, the metaphors of ardour, he ascribes to the electrical phenomenon 'the difference in the vigour of those who are chaste and of those who abandon themselves immoderately to pleasure'.

For La Cépède, 'the electric fluid is for plants what love is for sentient beings, with nevertheless this difference, that for plants it is but the cause a tranquil, peaceful existence'. There then follows, in this book on electricity, a passage showing that in humans, love is 'a source of pain and unhappiness'. We then come back to plants that 'grow and multiply without jealousy and pain'. The electric fluid is, he writes, so healthy and invigorating for plants that they:

> are not troubled by fear of storms, thundering nature being for them but a tender mother who comes to provide for their needs; and if sometimes the tallest trees are harmed by what is but the greatest good for humbler plants, examples in a way of a devotion rarely found among us, they can be said to offer their topmost part to the lightning that must strike them, seeking thus to protect from it the tender plants and young shrubs that grow in the shade of their branches.

There are many pages offering a 'rational' explanation of this grandiose intuition and this tender affection. The writer asks this question: what secret means does the electric fluid give plants the strength to grow spread, and is the electric fluid in some way necessary to their reproduction?' This secret means is sap. It is springtime rain, charged with lightning.

then should not men water their gardens with electrified water? And then there is the experiment endlessly referred to in the eighteenth century of the two myrtle trees in Edinburgh that were electrified in the October of 1746 and were then covered with buds.[19]

We might accept such 'harmonies' from someone like Bernardin de Saint-Pierre, excusing them as a literary device. They are harder to accept from a writer whose only ambition is to be scientific. They confirm our view that an animist philosophy is more easily admissible in its general inspiration than in its particular proofs, in its over-all views rather than its specific ones, at its summit rather than its base. But what then are we to think of such a philosophy and how can we explain its success? A philosophy is not coherent because of its object; its only cohesion is that of the community of the affective values held by writers and their readers.

X

We shall now try to condense all the observations made here with a view to establishing a psychoanalysis of objective knowledge. We shall do so by showing the enormous value forming around the idea of seed, germ, and grain, an idea that is used as a synonym for a substance with a value above and beyond what is strictly the domain of life; we shall also continue to follow the path of animism.

Let us look first at gratuitous, unproven valorisations, which are plainly a priori.

Intensity, concentration, and purity are ascribed to the germ. Thus Charas says, without offering any comment as though referring to something self-evident, 'seed is the purest and the most elaborated part that an animal can produce, and it is also accompanied by many spirits'.[20]

More than a century later, the same valorisation is implicit in what is in fact a general transmutation of substantial values. In 1788, Roy Desjoncades writes as follows:

> Is not man's seed composed of the subtlest part of his food which, when digested and perfected by its last coction, is then diffused in all parts of his body? Now, does not the food that furnishes this seed come from the universal seed, diffused in the upper regions and then cast deep into the bosom of the earth, where it is cooked and digested, and from thence distributed to all mixts for their maintaining? Thus, since this seed is found then in all the minerals, plants, and animals from which man takes both food and medicaments to sustain his life, man's seed emanates therefore

from the universal seed.

Here we see a very substantial panspermy that valorises human life by making human seed the quintessence of the universal seed. In fact, Guy de Chauliac says that this seed 'when perfected in apparatus of marvellous design ... has become one of the most precious of elixirs'. Such a theory is at the root of sexual deviations, many examples of which can be found in the work of Havelock Ellis.

Value is so thoroughly incorporated into seed that people readily accept the view that, in the words of an anonymous author writing in 1742, 'the smallest seeds are indeed the hardiest, the most fertile, even producing the largest things'.[21] We recognise the valorised union here of what is small and what is precious.

Germ is the most *natural* of all things, and the least alterable. It must be treated as *naturally* as possible. The Abbé Poncelet links his entire theory of agriculture to this first intuition, stating that:

> I believe that Nature's wish, in the reproduction of plants, is to lay the new germ into the earth as soon as it is formed. Delaying this operation, which is perhaps the most essential of all (in the harvesting and storing of grain), means running the risk of weakening the germ by diseases we do not even suspect; it means impoverishing the milky substance in which they swim, so to speak, and which must serve as their first food.

There then follows the agricultural corollary of this vitalist philosophy: 'Since germ, from the first moment of its formation, continually tends towards development, it cannot be laid too soon in an appropriate womb ... Thus, seed-time should not be very far from harvest'. For this natural philosophy, the earth is of more worth than granaries.

Germ's action is often ascribed to a more inward principle. Though seeds are diverse there is but *one* principle. Substantialist and animist come together and *realise* this unity. Thus, Crosset de la Heaumerie writes:

> Everyone, however unenlightened, knows that the thing's true seed is neither grain nor sperm but the essential, constituent matter of such a being, that is to say a certain mixture of the subtle element in certain precise proportions, which make a thing such as it is and with certain properties; everyone also knows that this seminal essence is enwrapped by other, crude elements that hold it, lest it should by its subtlety evaporate.

Here we see in all its clarity the myth of interiorisation. The seminal spirit is also seen to be a true reality. Nicolas de Locques writes that 'The seminal spirit is the Architect of essential forms ... just as the volatile salts are of accidental forms; the one appears to us rising up in the form of a vapour, smoke, or imperceptible exhalation, the other in the form of all volatile things that are meteorised[22] in the form of a thicker vapour, either damp or dry'.

We can therefore understand that germ, if not love, is stronger than death. There is still today much that appeals to people in the arguments – which remain imprecise – to the effect that the *germen* is eternal while the *soma* decays. Robinet put his vitalism into a form concurring with his religious beliefs, saying that 'we shall be resurrected in only a germinal state'.

Everything that grows shares in the nature of germ or seed. For the anonymous author of a *Nouveau Traité de physique*, writing in 1742 'the buds on the Trees are not very different from their seed'. This clearly proves that the germ is now only the subject of verb to germinate. More generally still, the germ is a substantive corresponding to the *realism of growth.*

Growth is thus felt from the inside, as it were, rather than being studied in its phenomena, in its structural modifications. It is therefore highly symptomatic that, in pre-scientific biology, the germen was a force rather than a form, a power rather than a structure. This lack of discursive objectivity is at the root of some very curious beliefs and we shall now offer a few examples of these.

Digby seeks to draw vital juices from animals he crushes and grinds up. He distils crayfish; what remains is calcined, dissolved, and filtered. The salt is recovered through the distilled product; it does not take long for this cohobation to produce 'crayfish as big as millet seeds'.

In a very famous book – *Curiositez de la Nature*, published in 1709 – the Abbé de Vallemont speaks of a kind of water that is generative. He states that 'In ordinary water there is water of another kind that I call *Germinative* for Plants, *Congelative* for minerals, and *Generative* for Animals, without which there is nothing that could say; I am'.

This germinative intuition becomes more precise however and claims to have useful applications. The Abbé de Vallemont boils a bushel of corn in five buckets of water. He then feeds the corn to the fowls so that nothing is lost but it is the water that it was steeped in that is precious. It can stimulate the germination of all other seeds and also the growth of all other plants. 'A quart of this water', he says, 'poured at the foot of a young tree is a delight to it and makes it work wonders. And it would not harm old trees. A vine would be very glad of it and would repay this kindness a hundredfold when the

grapes come to be harvested.' So convinced is the Abbé de Vallemont that germination is *condensed* in this water of his that he proposes to add fertiliser, saltpetre, and liquid manure directly to the water in which the corn had been sown.

Plants are not the only things to benefit from the power of this germinative water. The Abbé de Vallemont also says that 'Animals will indeed grow and become fine specimens if this liquor of increase is used for moistening their bran and steeping their grain'. And he goes on thus: 'I know from experience that when a little of this liquor is added to a horse's oats, that horse will render services we cannot imagine. There is no obstacle it cannot clear, and no difficult situation it cannot overcome ...Cows repay the cost this liquor with an amazing abundance of milk. Hens repay us with eggs. Everything multiplies ... Everything is lively and agile'. And the Abbé de Vallemont adds this, giving away the nature of his unconscious conviction: everything in the farmyard is feeling frolicsome.[23]

This is not an isolated intuition. Forty years later, in 1747, the Abbé Rousseau, 'the former Capuchin and doctor to his Majesty', claims that grain that has been infused in an alcoholic spirit made with corn will germinate 'much more vigorously because this Eau-de-Vie which contains the vegetative essence of the grain from which it was made, having been imbued with this grain, fortifies its own fertility and by its ferment, gives swifter movement to the grain infused in it, like leaven that makes another batch of dough to rise'.[24] However, too much alcohol must not be used, he adds, because the grain 'would disanimate'. We get the feeling that he has performed experiments that turned out to be *negative*: grain steeped in alcohol at too high a concentration did not grow. *Positive* experiments in which the macerations were shown to be indifferent and ineffective were given weight by animist valorisation. The Abbé Rousseau continues, giving his intuition the status of a major principle: 'It is according to this rule that Philosophers speak of their imbibitions in order to resurrect and reanimate the skulls they seek to volatilise; little by little they restore to them, by a copious and dominant affusion, the soul or spirit they had removed from them'. Thus, 'the eau-de-vie has in it a fertility principle, no matter what changes may have befallen the appearance of the Plants from which it is taken'. In all these examples, there is nothing metaphorical about the *fertility principle*. It is not something abstract: it is an *extract*. Hence, it does not matter whether the corn is in the earth or 'crushed and milled into flour, turned and mixed in dough, or even soaked in the brewer's vat'. Whether it is planted, eaten, or drunk, it is always the same fertility principle that renews both plants and humans. *Ubi virus ibi virtus*.[25] Seminal power is the supreme power; it totalises and sums

up all actions and all powers. 'I have always believed', the Abbé Rousseau says, 'that Physical virtue lies in the essential, seminal principle of every being'. He goes on to state more precisely that 'I say that the same seminal being of the Poppy, which is capable of producing its plant, is also capable of producing the effects it has in Medicine'. We sense how *concrete* and therefore incorrect this intuition is and how far it is from the philosophy of modern chemistry, for which the extraction of opium is instead disindividualisation and deconcretisation. Moreover, synthetic preparations based on chemical elements are proof of this very modern substitution of the abstract for the extract.

H.G. Wells's novel *The Food of the Gods*[26] is based on similarly ingenuous intuitions; under its scientific verbiage, it would be easy to find the simplistic beliefs we have noted in the myth of digestion and also in the myth of the universal seed. The 'theory' of uninterrupted growth which is Wells's guiding idea here can already be seen in the Abbé de Vallemont's fanciful practices. This makes it very clear that the novelist's success as a populariser is solely due to the stock of ideas he draws on, the permanence of which by no means proves their value.

XI

A full psychoanalysis of the scientific unconscious should undertake a study of feelings that are more or less directly inspired by the libido. It should in particular examine the will to power that the libido exercises over things and animals. This is no doubt a deviation of the will to power which, in the full meaning of the term, is the will to dominate humans. This deviation is perhaps a form of compensation. It is at any rate very clear when faced with reputedly dangerous representations. We shall provide only one example which, we believe, comes under a particular kind of psychoanalysis. This is the case of fallen pride, of ostentatious power that is the mark of latent impotence. We shall see a proud thaumaturge caught in his own trap.

The sight of certain objects or living beings carries such a weight of emotion that it is interesting to detect weaknesses in the bold minds that pride themselves in studying them. The following is an amusing story told by the Abbé Rousseau:

> Van Helmont says that if you put a toad in a vessel sufficiently deep for it not to escape and if you stare at it, this Animal will, having made every effort to jump out and escape, then turn round, stare at you, and a few moments later fall down dead. Van Helmont attributes this effect to the

> idea of dreadful fear the toad conceives at the sight of a human. Assiduous attention leads to this being so stirred up and heightened that it suffocates the animal. I have therefore done this four times and have found van Helmont to have told the truth here. A Turk present in Egypt where I performed this experiment for the third time, on seeing this exclaimed that I was a saint for having killed by sight of me an animal they believe to have been produced by the Devil.

Here we see the thaumaturge in all his glory! Let us now see the defeat that will allow us to see very clearly the true ambivalence of *courage* which is so badly used. The Abbé Rousseau continues thus:

> However, having wished to do the same thing for the last time in Lyon ... far from the toad dying, I thought I myself was going to die. Having tried in vain to climb out, this animal turned towards me; and swelling to an extraordinary degree and raising itself on all four feet, it breathed impetuously without moving from its place, looking at me with unwavering eyes that I saw grow perceptibly more red and fiery; at that moment a universal weakness overcame me, which all of a sudden led to fainting accompanied by a cold sweat and loosening of the bowels and bladder. As a result, I was thought dead. I had nothing then to hand other than Theriac and powder of Viper, of which I was given a large dose that enabled me to recover my senses; I continued to take this both morning and evening for the eight days this weakness lasted. I do not have leave to reveal all the remarkable effects of which I know this frightful animal to be capable.

This passage seems to us an excellent example of the *concretisation* the fear that troubles so many pre-scientific cultures. The valorisation of powder of viper is partly out of fear that has been overcome. Triumph over pugnance and danger is sufficient to valorise the object. The medicament then a trophy. It can be a very effective aid to *repression*, a repression that is somehow materialised and that can help the unconscious. We would be ready to entertain the theory that foolish remedies are needed to treat foolish people and that the unconscious needs to be *unburdened* using methods that are both crudely materialist and crudely concrete.

We see then that if we wish to measure the obstacles that stand in the way of objective knowledge, of tranquil knowledge, it is human beings as a whole that we must consider, human beings with their heavy burden of ancestrality and unconsciousness, and with all their confused, contingent

youthfulness. Alas, teachers show little interest in imparting this tranquillity. And consequently, they do not guide pupils towards knowledge of the object. They judge rather than teach. They do nothing to cure the anxiety that grips every mind faced with the need to correct its own thought and go beyond itself in order to find objective truth.

NOTES

1 Bachelard refers here to *The Dialectic of Duration*, published in fact in 1936, which he describes as 'an introduction to the teaching of a philosophy of repose', thus indicating that he is at work on *The Formation of the Scientific Mind* well before 1938 and that he is reflecting on these two books concurrently. See *The Dialectic of Duration*, trans. Mary McAllester Jones (Manchester: Clinamen Press, 2000), 17.

2 Bachelard's footnote: Anonymous, *Le Triomphe hermétique ou la pierre philosophale victorieuse, traité plus complet et plus intelligible qu'il y ait eu jusques ici, touchant le magistère hermétique*, 2nd ed. (Amsterdam: 1710).

3 Bachelard's footnote: Anonymous, *La Lumière sortant de soi-même des Ténèbres ou Véritable théorie de la Pierre des philosophes*, trans. from the Italian, 2nd ed. (Paris: 1693).

4 'Artist' is used here in the sense of 'alchemist'; alchemical texts refer to 'the Art of Alchemy', often abbreviated to 'Art'.

5 Bachelard's footnote: D***, *Rares expériences sur l'esprit minéral pour la préparation et la transmutation des corps métalliques* (Paris: 1701).

6 Bachelard's footnote: *Dictionnaire hermétique* (Paris: 1695).

7 Bachelard's footnote: Anonymous, *Le Triomphe hermétique*; see note 2.

8 Bachelard's footnote: Anonymous, *Histoire de la Philosophie hermétique, avec le Véritable Philalèthe*, 3 vols. (Paris: 1742).

9 Bachelard's footnote: Abbé D. B., *Apologie du Grand Oeuvre ou Élixir des philosophes dit vulgairement pierre philosophale* (Paris: 1659).

10 Bachelard's footnote: Anonymous, *Histoire de la Philosophie hermétique*; see note 8.

11 'Philosophers' is another term used for alchemists, alchemy being referred to as 'the Philosophical Art'.

12 Bachelard's footnote: Anonymous, *Le Traité d'Alchymie et le songe verd* (Paris: 1695).

13 Bachelard is alluding here to the first line in Mallarmé's poem 'Brise marine' ('Sea Breeze'): 'The flesh is sad, alas! and I have read all the books'.

14 Bachelard wrote the preface for the French translation of Martin Buber's *Ich und Du*, entitled *Je et tu*, trans. G. Bianquis (Paris: Aubier, 1938).

15 While Bachelard quotes in Italian from d'Annunzio's novel *Il Fuoco* (*Fire*), he

refers to the French translation. I am grateful to Dr Philip Cooke for the following translation of these lines:

Throbbing with the life of the elm
and the vine plant
The gentle succour
Of fertility.

16 A Latin proverb: 'When the cause is taken away, the effect is removed'.

17 Bachelard's footnote: W. Whewell, *History of the Inductive Sciences*, 3 vols. (London: 1857).

18 Bachelard's footnote: Jallabert, Professor of Experimental Philosophy and Mathematics, Member of the Royal Societies of London and Montpellier and of the Academy of the Institute of Bologna, *Expériences sur l'électricité avec quelques conjectures sur la cause de ses effets* (Paris: 1749).

19 Joseph Priestley reports this experiment in his *History and Present State of Electricity*.

20 Bachelard's footnote: Charas, *Suite des nouvelles expériences sur la Vipère* (Paris: 1672).

21 Bachelard's footnote: Anonymous, *Nouveau Traité de physique* (Paris: 1742); see Chapter 6, note 29.

22 To meteorise is to vaporise, to convert into vapour.

23 Bachelard plays on the word 'gaillard' here, which in addition to meaning merry or lively has a mildly sexual connotation, used for instance to describe stories as 'naughty' or 'spicy', and songs as 'ribald' or 'bawdy'.

24 Bachelard's footnote: Abbé Rousseau, *Secrets et Remèdes éprouvés dont les préparations ont été faites au Louvre, de l'ordre du Roy* (Paris: 1747).

25 'Where there is slime, there is goodness'.

26 H. G. Wells, *The Food of the Gods and how it came to earth* (London: 1904); Bachelard refers to the French translation entitled *Place aux Géants* (Paris: 1904).

Chapter Eleven

The obstacles to quantitative knowledge

I

Immediate objective knowledge is necessarily incorrect by virtue of the fact that it is qualitative. It produces error that must be rectified. It lays an inevitable burden of subjective impressions on the object; objective knowledge must therefore be unburdened; it must be psychoanalysed. Immediate knowledge is subjective in its very principle. By regarding reality as its own possession, it gives premature certainties that hinder rather than help objective knowledge. This then is the philosophical conclusion that we believe can be drawn from the preceding chapters. It would be a mistake moreover to think that *quantitative* knowledge escapes in principle the dangers of qualitative knowledge. *Size* is not automatically objective and we only have to move away from familiar, everyday objects to meet with the oddest of geometrical determinations and the most whimsical of quantitative determinations. Since the *scientific object* is in some ways always a *new* object, we can understand at once that first determinations are almost inevitably inappropriate. Lengthy studies are necessary before a new phenomenon can give rise to the correct variable. Thus, when we follow the development of electrical measurements, we may be surprised to see how late Coulomb's work comes. Vitalo-meters are still being proposed late into the eighteenth century, these being devices based on electrical action which, while doubtless striking and immediate, is also complicated and therefore ill suited to the objective study of the phenomenon. Conceptions that are apparently very objective and very clearly represented, and quite obviously part of a precise geometry, as Cartesian physics is, are strangely lacking in a theory of measurement. Reading Descartes's *Principles of Philosophy*, one could almost say that size is a *quality* of extension. Even when it comes to teachers as vigorous and clear as Rohault, pre-scientific explanation does not appear to

be part of an obviously mathematical theory. This point has been well made in Paul Mouy's excellent book entitled *Le Développement de la physique cartésienne* when he says that 'Cartesian physics is mathematical physics without mathematics. It is a concrete geometry'.[1] This immediate geometrism, lacking as it does a discursive, explanatory algebra, manages not to be a mathematism in the strict sense of the word.

These remarks will become more pertinent if we try to describe the influence of the human scale of things on all our value judgements. There is no need to go back over the points so often made to the effect that the Copernican revolution meant that humans were faced with a new world scale. The same problem arose throughout the seventeenth and eighteenth centuries but from the other end of the scale, with microscopic discoveries. Today, breaks in scale are increasingly frequent. Yet the philosophical problem has always remained the same: human beings must be made to disregard the ordinary, everyday scale of things, that is to say *their* own scale; they must also be made to think the scale or size of things relative to the method of measurement; in short, they must be obliged to take what comes to them in the most immediate of intuitions and make it clearly discursive.

However, since epistemological obstacles come in pairs, we shall see that in the realm of quantity itself the attraction of an all too vague mathematism has an opposite, the attraction of a mathematism that is all too precise. We shall endeavour to characterise these two obstacles in their elementary forms, using examples that are as simple as possible, for if we had to determine all the difficulties of forming phenomena mathematically, we would have to devote an entire book to this. Such a book would take us beyond the problem we wish to describe in this present volume, namely *the first formation of the scientific mind*.

II

Excessive precision in the realm of quantity corresponds very accurately to excessive vividness in the realm of quality. Numerical precision often consists of a figures run riot just as the vivid and picturesque is, in Baudelaire's phrase, 'detail run riot'. One of the clearest signs of a non-scientific mind can be seen here, just when such a mind has pretensions to scientific objectivity. Indeed, one of the scientific mind's primary requirements is that the precision of a measurement must constantly be referred to the sensitivity of the method of measurement, and that it must of course take account of the conditions of permanence of the object being measured. When a fleeting or indeterminate object is *accurately* measured or when a fixed and

clearly determined object is *accurately* measured with a crude instrument, then we have two kinds of pointless occupation that science refuses from the very outset.

This apparently insignificant problem of measurement also shows us the divorce between the thought of realists and scientists. Realists will immediately take hold of a particular object in their hands. It is because they possess it that they describe and measure it. They measure it exhaustively, down to the last decimal point, just as a notary will count a fortune down to the last farthing. Scientists on the other hand *approach* this initially ill-defined object. They first of all *get ready* to measure it. They discuss the conditions for studying it; they determine the sensitivity and scope of their instruments. Lastly, it is their *method of measurement* rather than the *object to be measured* that scientists describe. The measured object is little more than a particular degree of approximation in the method of measurement. Scientists believe in the *realism* of measurement rather than in the *reality* of the object. The nature of the object can therefore change when the degree of approximation changes. Claiming that you can, at a stroke, exhaust quantitative determination means that you are overlooking the object's *relations*. The more relations the object has with other objects, the more instructive it is to study that object. However, relations are subject to interference once they are numerous, making discursive investigation by approximations an immediate methodological necessity. Objectivity is affirmed then within measurement as a discursive method, and not beyond measurement as the direct intuition of an object. We must reflect in order to measure and not measure in order to reflect. Were we to aim at a metaphysics of methods of measurement, we would need to address ourselves to critical philosophy, not realism.

Let us however watch the pre-scientific mind in its rush to reality and see it asserting itself in exceptionally precise detail. We can observe all this in either what teachers come across everyday in their lessons, or the history of science, or else the practice of a number of nascent sciences.

The physics problems that pupils have to do for the baccalaureate examination would give us an inexhaustible supply of this ill-founded precision. Most of the numerical applications are gone through without any concern for the problem of error. It only takes a division that 'goes all wrong' or calculations that 'will not work out right' to make candidates panic. They keep on dividing and dividing, in the hope of getting an accurate result. If they stop, it is because they think that a solution's merit can be measured by the number of decimal points given. They do not reflect that when precision concerning a *result* goes beyond that concerning *experimental data*, what that precision in fact determines is nothingness. The decimals in a calcula-

tion do not belong to the object. When two subjects such as mathematics and physics interfere, one can be pretty sure that pupils will not harmonise the two 'precisions'. Thus, with a view to teaching healthy approximations, I have often set the following simple problem: calculate to the nearest centimetre the average radius of an oak tree with a circumference of 150 centimetres. The vast majority of the class would do the calculation using the stereotypical value of p = 3.1416, which is obviously way beyond the degree of precision possible. I have similarly pointed out elsewhere,[2] when expounding on an illuminating page of Borel's, the disharmony in precision arising when the price you pay for a building plot in Paris is worked out to the last centime whereas the land is measured at the very most to the last square decimetre, with the price of a square decimetre having an effect on the number of francs paid out. This practice makes us think of Dulong's joke about an experimenter who, while sure about the third figure after the decimal point, will hesitate about the first one.

In the eighteenth century, an entirely gratuitous excess in precision is the rule. We shall only give a few examples of this here in order to make the point clear. Buffon for instance reaches 'the conclusion that 74,832 years ago, the Earth had been separated from the sun due to the impact of a comet, and that in 93,291 years' time it will have cooled down so much that life will be no longer be possible there'.[3] This ultra precise prediction is especially striking given that the physical laws on which it is based are of the vaguest and most particular.

In the *Encyclopédie*, there is an article entitled 'Bile' where we can find the following precise determination provided by Hales: gallstones give 648 times more air than their volume and kidney stones give 645 times their volume. Accustomed as we are to looking carefully at experimental error, we will see these different but similar figures produced by a somewhat crude technique not as the sign of substantial difference, as Hales does, but rather as proof of experimental identity.

Concern with precision also leads some minds to pose meaningless problems. Father Mersenne asks 'Pray tell me how much further a man who was six foot tall would journey with his head than with his feet were he to walk around the Earth'. Given the very rough knowledge of the earth's radius at that time, we can see the geometrical absurdity of the problem posed by Father Mersenne, in addition to the question's complete lack of meaning. At the end of the eighteenth century, Bernardin de Saint-Pierre observes the flight of houseflies. Some 'would rise in the air, flying against the wind, using a mechanism roughly similar to that of paper kites, which as they rise form an angle of, I believe, twenty-two and a half degrees to the axis of the

wind'.[4] Here, 22.5° has obviously been given because it is half of 45°. The author wanted to make a vision geometrical. The idea of obliquity seemed too vague to him. Moreover, he doubtless thought that the best and simplest obliquity corresponded to 45°. Puerile calculation, as we see, comes to the aid of an inappropriate need for precision.

The quest for false precision goes hand in hand with the quest for false sensitivity. Madame du Châtelet offers us this reflection, as if it were some learned thought: 'Since Fire expands all bodies and since its absence contracts them, bodies must be more expanded by day than at night-time, houses must be higher, people taller, etc., and thus everything in Nature is in perpetual oscillations of contraction and expansion, which uphold movement and life in the Universe'.[5] We see moreover how lightly the pre-scientific mind associates general views with particular and meaningless facts. Madame du Châtelet continues thus, mixing different kinds of things:

> Heat must expand bodies at the Equator and contract them at the Pole; this is why Lapps are small and strong, and it is very apparent that the Animals and Plants that live at the Pole would die at the Equator, and those of the Equator would do so at the Pole, unless they were carried there by imperceptible gradations, just as Comets pass from their aphelion to their perihelion.

Arithmetic is sometimes applied in determinations where it is not required. We can thus find the following incredibly precise details in the article on 'Air' in the *Encyclopédie*: 'It has been demonstrated that the perspiration of under 3,000 people standing on an acre of land would after 34 days form an atmosphere about 71 feet high, which would very soon become pestilential if it were not dispersed by the winds'.

Lastly, eighteenth-century writers and today's baccalaureate candidates are not the only ones with the bad habit of giving inappropriately precise details: there are entire sciences which have not determined the scope of their concepts and which forget that *under no circumstances* should the exactness of numerical determinations exceed the means of detection. Geography textbooks, for instance, are currently stuffed with numerical data whose variability and area of exactness are not fixed. A textbook used in classes of thirteen-year-olds inflicts on them precise details such as the following: the average annual temperature in Menton is 16.3°. There is a paradox here, for the average is worked out to a tenth of a degree while in fact the practical use of climatic data makes do with degrees. The same author, like very many others, gives excessive precision to the concept of population density, a con-

cept which is clear and useful if allowed its appropriate indetermination. The offending textbook tells us that in the department of the Seine, the population density is 9,192 inhabitants per square kilometre. This *fixed* number for a *floating* concept, which in its exact form is not valid for even an hour, will be used, along with others like it, to 'teach' our pupils for ten years or so. The geography textbook written by the same author for pupils preparing for the baccalaureate contains 3,480 numbers which nearly all have the same scientific value. This numerical overload forces pupils to remember more than 100 numbers per hour-long lesson. This is the excuse for a loathsome teaching method that, though flying in the face of common sense, is becoming widespread in subjects that are scientific in only a metaphorical sense.

III

More clearly still and, so to speak, materially, the different ages of a science could be determined by the techniques of its measuring instruments. Recent centuries have all had their own particular scale of precision, their own group of exact decimals, and their own specific instruments. It is not our wish to go back over the history of instruments that we have already discussed in another book.[6] All we want to do is to show the difficulty of determining the *first* conditions of measurement. For example, Martine reminds us that there was much imprecision in the construction of the first thermometers: 'Even those made in Florence were far too vague and indeterminate, their highest degree being fixed in accordance with the Sun's greatest heat in that region'.[7] From just this one example, we realise how disastrous the direct use of a thermometer was. Since a thermometer ought to give us information about the ambient temperature, meteorological indications will be looked to first of all to provide the principle of its scale. With a similar view in mind, Halley suggests taking as a fixed point the temperature of subterranean areas that are indifferent to both winter and summer. This indifference was recognised by the thermometer. It was not directly objective in the absence of measurement by an instrument. Even in Boyle's time, Martine observes, 'thermometers were so variable and so indeterminate that it seemed morally impossible to establish by this means a measurement of heat and cold in the same way that we have a measurement of time, distance, weight, etc.'.

Given this lack of instrumental technique, we should not be surprised at the enormous variety of the first thermometers. There were soon more types of thermometer than there were measurements of weight. This variety is very characteristic of a science pursued by amateurs. In a scientific community constituted as ours is, instruments are almost immediately standardised.

The technical will is nowadays so clear and kept under such close surveillance that we are surprised at the early margins of error. We believe that the construction of an *objective piece of apparatus* is self-evident and we do not always see the number of technical precautions required when assembling the simplest apparatus. Is there, for example, anything apparently simpler than putting a barometer together as in Torricelli's experiment? Yet just filling the tube requires very great care. The slightest error here, the tiniest bubble of air left behind, will determine appreciable differences in barometric height. Romas, an amateur scientist living in a little town called Nérac, followed the different variations of some fifty of these instruments. At the same time, a large number of observations were made in order to fathom the influence of barometric variations on a variety of illnesses. Thus, the instrument and the object measured were both shown to be ill-adapted, with each of them a long way away from the correct conditions for objective knowledge. In early instrumental knowledge, the same obstacle can be seen to arise as in ordinary objective knowledge: the phenomenon does not necessarily make its most regular variable available for measurement. On the other hand, as instruments are improved, their scientific *product* will be better defined. Knowledge becomes objective in proportion to it becoming instrumental.

The idea of experimental sensitivity is a very modern one. Physicists must determine the sensitivity of their instruments before undertaking any experiment. This is what the pre-scientific mind does not do. Madame du Châtelet came close to the experiment Joule performed a century later but did not see its possibility. She explicitly says that: 'If movement produced Fire, then cold water when shaken up vigorously would grow hotter, but this does not happen perceptibly; and if it grows hotter, it does so with very great difficulty'. The phenomenon that hands cannot distinguish in any appreciable way would have been indicated by an ordinary thermometer. The mechanical equivalent of heat will be determined by simply studying this difficult warming process. This complete lack of experimental insight will be found less surprising if we consider the mixing-up of laboratory intuitions with natural ones. Thus Voltaire, like Madame du Châtelet, asks why the *violent* north winds do not produce heat. As we can see, the pre-scientific mind does not have a clear idea of the large and the small. It mixes up the large and the small. Perhaps what the pre-scientific mind most lacks is a theory of experimental error.

IV

In a similar way, the pre-scientific mind makes excessive use of reciprocal determination. In its view, there is interaction between all the variables characterising a phenomenon, and the phenomenon is considered to be equally sensitised in all its variables. Now, even if the variables are linked, their sensitivity is not reciprocal. Every piece of research must be made an individual case. This is what happens in modern physics, which does not postulate the over-determinism that is held to be unquestionable in the pre-scientific period. To enable these quantitative over-determinations to be fully grasped, let us give some examples where such over-determinations are especially shocking. Retz notes that there is no instrument available for estimating the quantity of electric fluid contained in the human body and then gets round the difficulty by turning to the thermometer. The relation between the entities of electricity and heat is very quickly established: 'Since the electric matter is regarded as fire, its influence in the organs of living bodies must cause heat; the rising or falling of a thermometer placed on the skin will therefore indicate the quantity of the electric fluid in the human body'.[8] And so a whole treatise goes awry; the author's often ingenious efforts lead him in the end to draw ingenuous conclusions such as the following: 'During the famous retreat from Prague, the bitter cold of this season deprived many soldiers of both electricity and life, and those who were left were only preserved by the care the officers took to whip them up and make them march and consequently electrify themselves'. It must be noted that the relation between electrification and body temperature is erroneous, that is to say given the sensitivity available to eighteenth-century thermometry; yet this experiment is done over and over again by many experimenters who register thermometric variations that are entirely insignificant. They think they are performing a physics experiment; what they are doing, and doing in very bad conditions, is an experiment on the physiology of the emotions.

With this guiding idea of the total correlation of phenomena, the pre-scientific mind resists the contemporary conception of a *closed system*. No sooner has a closed system been posited than there is a departure from this audacious idea and the pre-scientific mind affirms, with an unvarying stylistic device, the solidarity of the fragmented system with the Great Whole.

However, a philosophy of approximation that is well regulated, that carefully traces the steps taken when *effective* determinations are made, would lead to the establishment of phenomenological levels that escape minor disturbances *absolutely*. Yet this instrumental phenomenology, broken up by the *impassable* thresholds of operative sensitivity – the only phenomenology

we can indeed call scientific – cannot withstand the deep-rooted and unquestioned realism that seeks to save the continuity and solidarity of phenomena, in every one of their characteristics. This naive belief in a universal correlation, which is one of the favourite themes of naive realism, is all the more striking because it manages to unite heterogeneous facts. Let us give a splendidly excessive example of this. Carra's theory about 'the chain of causes that operate the different revolutions of the celestial bodies' leads him to give, from an astronomical point of view, precise details not just about the seasons of the planets but also about the properties of plants and animals, such as the colour of plants and life expectancy, all these details being of course gratuitous. Plants on Mercury are a very brownish green, and on Venus they are 'brownish green in the lands at one of its poles and golden yellow in the lands at the other pole'. On Mars, they are bright green. People live longer on Venus than on the earth. The longevity of Martians is 'a third less than ours'. Astronomical properties lead to everything else; everything fits in with them. Carra calmly suggests that Saturn enjoys unbelievable riches. It must have on it several billion beings similar to humans, and vast towns with between ten and twenty million inhabitants. In these all-embracing cosmologies, we can see Montesquieu's theory of climates, now extended to the universe, and this exaggeration exposes the weakness of Montesquieu's thesis. There is nothing more antiscientific than maintaining, either without proof or under the guise of general and imprecise remarks, that there are causalities between different orders of phenomena.

For centuries, pre-scientific minds have harboured these ideas of unlimited interaction, of interaction that can cross vast spaces and connect the most heterogeneous of properties. Such notions serve them as deep, philosophical ideas and are pretexts for every kind of false science. It could be proved that these are the fundamental ideas of astrology. Astrological *influences* are given a *material* character and this point is not always underlined by historians of astrology. As we have already noted, what the stars send us is not just signs and signatures but substances, a quantity rather than a quality. Seventeenth-century astrology knows full well that the light of the moon is simply reflected sunlight. Yet it is said in addition that in this reflection, a little lunar matter penetrates the reflected ray 'just as a whitewashed wall will leave a white mark on a ball that bounces off it'. The action of the stars is therefore the quantitative action of real matter. Astrology is materialism in the full sense of the term. The link we saw in the preceding paragraph between a star and its inhabitants is just a particular case of this all-embracing materialist system, a system based on general determinism. Few modifications are made over the centuries. Carra, writing at the end of the eighteenth

century, takes up the ideas of Father Kircher who a hundred and fifty years previously had *calculated* in accordance with the size of the planets in our solar system what the height of their inhabitants should be. While Carra is critical of Father Kircher, he rationalises the same hypothesis in his own way, providing a further example of on-the-spot rationalisation of manifest nonsense: 'for the inhabitants of the most dense of celestial bodies', he says, 'what we call blood will be a thick, black liquid circulating slowly in their arteries. For the inhabitants of the least dense celestial body, it will be a very subtle blue fluid circulating like fire in their veins'. This is followed by many, many pages where statements every bit as daring can be found. Hence then the sense of wonderment that very clearly shows the value accorded to a unitary conception of the universe, even though that identity is brought about simply by the quantitative concept of *density*. Thus, Carra exclaims: 'What vast objects for our meditation are we not given by the plurality of worlds, if we but consider this in all its respects! The greater or lesser density of the celestial bodies establishes an immense chain of varieties in the nature of the beings inhabiting them; the difference in their revolutions tells us of an immense chain in the duration of those beings'.

Scientific readers will no doubt accuse this example of being grossly and blatantly ridiculous. In our defence, however, we shall respond with the information that we have used this quotation as a test. We asked a number of educated people to reflect on these words and there was no reaction, not the glimmer of a smile on their impassive, worried faces. They all recognised one of the themes of philosophical thought here: everything in earth and heaven holds together; the same law governs both humankind and things. We have also set this text as an essay topic and never once has there been any attempt to *reduce* the fundamental error.

Yet there has to be an agreement to reduce the scope of determinism if we wish to pass from the philosophical to the scientific mind. It has to be affirmed that in scientific culture, *not everything is possible* and that only what has been shown as a possibility can be regarded as possible in scientific culture. This means resisting, courageously and sometimes at some risk, the mind that knows immediately and directly,' that will constantly eschew proof for presumption, the plausible for the possible.

This gives us what may be one of the features that best distinguish the scientific from the philosophical mind: we are referring to the *right to neglect*. The scientific mind formulates clearly and distinctly the right to neglect that which is negligible, and the philosophical mind tirelessly refuses it that right. The philosophical mind then accuses the scientific mind of proceeding in a vicious circle, retorting that what seems negligible is in fact

what is neglected. We can however prove the positive and active character of the principle of negligibility.

We have only to state this principle in a non-quantitative form in order to prove it to be positive. This is precisely why we value Ostwald's remark to the effect that 'whatever the phenomenon under consideration, there is always a very large number of circumstances that have no measurable influence on it'.[10] The colour of a projectile does not alter its ballistic properties. It may be of interest to see how exactly the scientific mind reduces useless circumstances. We know of Symmer's theory of two fluids, but what we perhaps do not know is that it could be said to have first been the theory of his two stockings. This is how Priestley describes Symmer's discovery of his vocation as an electrician:

> This gentleman had for some time observed, that upon putting off his stockings, in an evening, they made a crackling or snapping noise, and that, in the dark, he could perceive them to emit sparks of fire. He had no doubt but that this proceeded from the principle of electricity, and, after a great number of observations, to determine on what circumstances those strong electrical appearances depended, he found , at length, that it was the combination of white and black that produced the electricity, and that the appearances were strongest when he wore a white and black silk stocking upon the same leg.

While the chemical nature of the dye can doubtless come in here, scientific experiment would in fact look at chemical nature in its efforts to reduce a difference in action on the part of negligible circumstances such as coloration. This reduction was not easy, but its difficulty does serve to draw more attention to the need to reduce the interacting properties of phenomena.

The will to neglect is especially active in contemporary technology. A piece of apparatus can indeed be described negatively, if we may be allowed the expression, as well as positively. It is defined in terms of the perturbations it guards against, the technique isolating it, the assurance it gives that clearly defined influences can be neglected, in short in terms of the fact that it comprises *a closed system*. There is a whole complex of shields, casing, and immobilisers that fences in the phenomenon. All this *assembled negativism* that a piece of apparatus is in modern physics runs counter to the sloppy affirmations of the possibility of some undetermined phenomenological interaction.

The principle of negligibility is quite obviously fundamental to differential calculus, where it really is a proven necessity. The criticisms of a rather

belated Cartesian like Father Castel are therefore all the more striking because of this. He notes Newton's frequent use of the expression 'which can be neglected' and roundly condemns it. Thus in the realm of quantity, where the principle of negligibility is so plainly triumphant, he reiterates attacks that are equally unfounded in the realm of quality.

V

The pre-scientific mind is guilty of a similar confusion when it fails to recognise realities of scale. It transfers the same experimental judgements from the small to the large and from the large to the small. It resists the pluralism of magnitudes that is however essential to a reflective empiricism, despite the attraction of the simple ideas of proportionality. A few examples will suffice to show how lightly some will pass from one order of magnitude to another.

One of the most characteristic features of eighteenth-century cosmogonies is their brevity. Those of Buffon and the Baron de Marivetz are fairly detailed, but they are rudimentary in principle. Sometimes only an image or a word is necessary. In just a few lines and simply by referring to an everyday experience, the world is explained; there is no sense of unease about going from the small to the large. Thus, the Comte de Tressan refers to the explosion of Prince Rupert's drop, which was just a drop of molten glass plunged into cold water,[11] in order to explain the explosion that 'separated the Planets' matter from the Sun's mass'.

A member of the *Académie* suggested the following programme to his colleagues in order to judge the validity of the Cartesian hypothesis regarding vortices: 'a pond should be chosen so as to make its water go round and round in the middle, communicating its movement to the rest of the water by different degrees of velocity; the movement of the different bodies floating in different parts and at different distances from the middle should be examined, so as to make a comparison with the planets of the world'.[12]

When the microscope suddenly increased human experience of the infinitely small, it was quite natural to turn to biological proportionality, posited without any proof or measurement, in order to make the depth of this infinity understandable. De Bruno is still referring in 1785 to this argument of Wolf's, an argument lacking any objective foundation: 'The space of a barley grain can contain 27 million living animals, each with twenty-four feet ... the smallest grain of sand can serve as the home of 294 million organised animals, which propagate their species and which have nerves, veins, and fluids that fill them and that are doubtless in the same proportion to the

bodies of these animals as the fluids of our body are to its mass'. It is remarkable that a reality that belongs as clearly as a living body does to a typical order of magnitude should be minimised in this way by certain pre-scientific minds, without even the slightest proof being offered. It should also be noted that the myth of the contained allows a numerically precise content (294 million living beings) to be determined here in an imprecise container that can double in size (a grain of sand). Mention has often been made of even bolder assertions on the part of observers who claimed they had discovered infusoria – a class of protozoa – with human faces. Maillet noted that human skin appeared under the microscope to be covered with 'small scales' and regarded this as confirming his thesis of humankind's marine origins. Microscopic observations were the occasion of the most incredible views, with the exception of those patient, constantly *repeated* observations made by highly talented observers, which took them beyond their first sense of wonderment.

We must stress moreover that reflections on the two kinds of infinity were each very different in their affective tonality. When the two infinities were multiplied, so to speak, by the invention of the telescope and microscope, it was hardest to reach a state of calm where the infinitely small was concerned. This asymmetry in scientific terror did not escape Michelet, who provides this rapid parallel in his book on insects:

> There is nothing more curious than to observe the very contrary impressions that the two revolutions had on their originators. Seeing the infinity of the sky, where everything seems harmonic and wonderfully calculated, Galileo feels more joy than surprise; he announces the news to Europe in the most jovial style. Seeing the infinity of the microscopic world, Swammerdam seems terror-struck. He draws back from the abyss where nature does battle and devours itself. He grows agitated; he seems to fear that this will shake all his ideas and beliefs.[13]

While these reactions are no doubt influenced by particular psychological factors, they can serve even so to prove the rather strange affective value we ascribe to phenomena that suddenly become far distant from our own order of magnitude. The frequent lessons in humility we are given by pre-scientific writers and also by present day popularisers make it very clear that there is resistance to leaving this familiar order of magnitude.

This resistance to going beyond the biological level at which knowledge of human life operates has now been completely reduced, and so too have been these attempts to transfer the human to the elementary forms of life. The memory of this success on the part of biological objectivity should

perhaps help us overcome present-day resistance to atomic objectivity. What hampers contemporary scientific thought, if not for its creators then at least for those charged with teaching it, is attachment to everyday intuitions and reference to the ordinary experience that belongs to our *order of magnitude*. The only thing to be done then is to break with habits. The scientific mind must combine flexibility and rigour. It must revise all its constructions when it approaches new domains and must not impose the law of our familiar order of magnitude on everything. To quote Reichenbach, 'It must not be forgotten that in fact almost every new objective domain that is discovered in physics leads to the introduction of new laws'.[14] Nevertheless, this obligation is gradually becoming easier because scientific thought has experienced many revolutions over the last hundred years. Things were very different though when the first fracture occurred. Abandoning common-sense knowledge is a difficult sacrifice to make. We ought not to be surprised at the ingenuous response to the first descriptions of an unknown world.

VI

It can easily be shown moreover that the mathematisation of experience is not helped but hindered by familiar images. These vague, crude images present a picture on whose lines geometry can have no hold. Thus, the refraction of light immediately finds its 'material image' which will put a stop to thought for a very long time by prohibiting 'mathematical demands'. An anonymous author writing in 1768 provides this rapid intuition: 'If you hammer a rather long nail into plaster or stone, this piece of iron will nearly always bend'.[15] This is all a non-scientific mind needs in order to 'understand' scientific experience. When I taught physics in junior classes at secondary-school level, I often had occasion to note that this 'material image' satisfies lazy minds quickly and disastrously. And even when precise proof is brought in, people go back to the first image. Thus, Father Castel is critical of Newton's clear work and seeks to prove the factitious nature of the concept of refrangibility used by Newton to explain the refraction of rays through a prism. Castel then invokes familiar images, among them that of bending a bundle of rods. Individually, he says, each of the rods has the same 'pliability'; however, putting them together in a bundle makes for differences and the rods on the outside of the bundle will bend less. The same thing happens when a bundle of rays is refracted... It is also very striking that when double refraction was discovered, the extraordinary ray was in several works allowed to float lawlessly beside the ordinary ray that was clearly designated by the law of sines. We read for example in the article on 'Iceland spar' in the

Encyclopédie that 'Of these two rays, one follows the ordinary law; the sine of the angle of incidence of the air in the spar is in the ratio of 5 to 3 to the sine of the angle of refraction. As for the other ray, it breaks in accordance with a particular law'. Indetermination peacefully coexists therefore with scientific determination.

There are sometimes even vaguer images that satisfy the pre-scientific mind, so much so that the question arises as to whether we ought not refer to a *real need for vagueness* which results in even the knowledge of quantity becoming rather woolly. Thus, Hartsoeker makes the following comparison in order to explain refraction: 'Nothing happens to a ray of Light other than what we could see happening to a man who, having passed through a crowd of children, would on leaving it meet obliquely with a crowd of strong and vigorous men, for assuredly this man would be turned from his path as he passed obliquely from the first crowd to the next'. There then follows an explanation, with an accompanying diagram, that claims to show the *refraction* of a man who is elbowing his way forward. This is no accidental paradox, such as those sometimes sparked off by the Anglo-Saxon eloquence of some professors. It is fundamental in fact to the explanation.

The refusal to give discursive mathematical form, where various approximations would be put into a series, is to the benefit of an *over-all form*, of a law expressed in a vague mathematics that satisfies the scant need for rigour of minds lacking in clarity. In 1787, Delairas, a doctor of the Sorbonne, writes a long book with the title *Physique nouvelle formant un corps de doctrine, et soumise à la démonstration rigoureuse du calcul*. You would, as it happens, look in vain for any sign of an equation here. And after enjoying a century of success, Newton's system is criticised here and conclusively refuted on several points, but without any examination of its various mathematical aspects. On the contrary, the author has faith in general forms such as the following: 'Every mass that occupies the centre of one of those areas of the universe called a *system* is but a compound of organic steps that double back on themselves and form all kinds of interacting movements. As these internal steps double back on themselves, they are subject to increases in velocity that come from accelerating faculties'. Seeing *imprecision criticise precision* in this way seems to us very typical. The author constantly refers to 'a natural geometry, within everyone's reach', thus maintaining that though there may not be a royal road to mathematical knowledge, then there is at least an open road, a route that anyone can take.

It is very striking that a 'mechanics' that refuses the characteristics of number always ends by describing the detail of mechanical phenomena using adjectives. For example, the Abbé Poncelet writes that 'There are as many

kinds of movement as there can be modifications to movement itself. There is movement that is straight, oblique, circular, centripetal, or centrifugal, or a movement of oscillation, of vibration, of electric shock, of vertigo, etc.'.

The Abbé Pluche's critiques show the same need for vagueness and the same search for direct qualifiers. In his view, Newton's law of gravitation, which is 'the increase or decrease of attractive powers in inverse ratio to the square of distance ... is the progress of all that is dispersed around us. It is the progress of smells'.[16] The question arises as to how such an accommodating general vision can be satisfied by an *increase* in power in accordance with the sphere of activity.

The same disdain for mathematics inspires Marat. After lengthy criticism of Newton's optics, he writes as follows:

> Here we see, in their true light, the abuse of science and the variety of mathematical speculation. For where have so many ingenious experiments, detailed observations, learned calculations, and deep researches led other than to an erroneous theory that a simple fact can irremediably overturn? And why have so many ingenious efforts, so many odd formulas, so many outrageous hypotheses, and so much wonderment been so profusely expended other than to make very clear the quandary in which the Author finds himself?[17]

Given the psychoanalytical standpoint we are taking here, we need to ask ourselves whether the *quandary* in which Newton is accused of finding himself does not prove the reader's quandary when faced with the mathematical difficulties of Newton's work. Hostility to mathematics is a bad sign when it goes hand in hand with the claim to lay direct hold on scientific phenomena. Marat goes as far as to write that Newton 'chased illusions, made a romance of physics, and wore himself out with ridiculous fictions, and always with nature before his eyes'.

VII

The theme of the *easiness* or *difficulty* of studies is in fact much more important than is thought. And this more particularly is not a secondary characteristic. On the contrary, from the psychological viewpoint adopted here, the *difficulty* of a thought is a primary characteristic. It is this *difficulty* that is expressed in very real physiological oppression, and that gives scientific culture its affectivity. It leads Marat, in his gentle period when he professes to be sensitive and courteous, to accuse Newton of chasing illusions and of

wearing himself out with ridiculous fictions. On the other hand, it is this same difficulty that, in a typically ambivalent way, attracts strong minds. Lastly, just by taking the theme of *relative easiness* we can show objective knowledge to have undergone an inversion as it passed from the pre-scientific to the scientific era.

It is not in fact unusual to see physics being regarded in the eighteenth century as easier than elementary geometry. Castel writes in the foreword to his physics that:

> Physics is in itself simple, natural, and easy, by this I mean easy to understand. We know its terms and we know its objects. We naturally observe and experience most things, light, heat, cold, wind, air, water, fire, weight, elasticity, duration, etc. Every glance is an observation of nature; every operation of our senses and our hands is an experiment. Every one of us is something of a Physicist, more or less according to how attentive and how capable of natural reasoning our minds are. *Geometry* on the other hand is very abstract and mysterious *in its object and its ways*, and even in its terms.[18]

I have several times set this text as an essay topic for students of philosophy, without saying who the author was. They mostly commented on it in glowing terms, seeing it as a fine expression of pragmatic arguments. This outdated text which the pre-scientific mind permeates through and through was soon turned into an active, actual theme by philosophical minds intoxicated with first intuitions and hostile to all abstraction.

It is indeed in relation to essential simplicity that Father Castel judges and condemns Newtonian science. He notes that Newton has inverted the order of pedagogical difficulties in the mathematical and physical sciences since you have to know integral calculus if you are to understand the movement of the stars and the phenomena of light. He sees this inversion as an anomaly to be rectified. His long book is written in order to put physics back in what he believes to be its good and rightful place, that is to say in its easy, immediate aspect.

Firstly, from the experimental point of view, simplicity must be maintained. Surprisingly enough, there were many physicists who did not succeed in doing Newton's experiment on the dispersion of light by a prism. What a lot of complications, they would say: 'You need prisms, and that's the easiest thing. You need a camera obscura. You need long rooms, and who among professional scientists has these? You need this and you need that, and you also need paraphernalia of a thousand something or others. And then

you need time and a sequence of a myriad very delicate operations, not to speak of certain powers of observation'. And then Castel concludes: 'in order to perform experiments on the refraction of light successfully, you would need to be a millionaire'.

Castel argues elsewhere in this book that:

> the colours of the Prism are but fantastical, speculative, and ideal ones, at the forefront of our minds and eyes ... How could Newton profess to have reached deep philosophical knowledge of colours if he only measured angles and lines? ... As regards colours, the only useful and substantial ones are the colours of painters and dyers. These can be handled, studied, put in all kinds of combinations, and subjected to real analysis. It would be surprising and yet it is very likely that Newton spent his whole life studying colours without ever taking a look at a Painter's studio or a Dyer's workshop, or at the very colours of flowers, seashells, and of nature.

Realist intuition is dominant here, as we can see. The pre-scientific mind wants a colour to be the colour of *something*. It wants to handle coloured *substance*. Putting colours together means in its view putting coloured substances together. Castel comes back to this question in another book. He regards *homo faber* as the grand master of physics. The more material a job is, the more it can teach us. He declares that 'dyers – and let this be said without causing offence to anyone – are the true Artisans of colour ...colours are the Dyer's sole end. For the Painter, they are but a means'.[19] Although the word 'spectral' does not have any worrying associations for us when used in a scientific context, at that time it linked the ideas of spectrum and spectre.[20] Thus, Castel writes that:

> I mistrusted the prism and its fantastical *spectral* colours. I regarded it as an enchanter's art, as a mirror that was not true to nature but by its brilliancy more fitted to flights of the imagination and to serving error, rather than to feeding the mind and drawing hidden truths from the deep well ... I regarded it with dread, as a reef revealed by the wreck of a famous ship, followed by a thousand other vessels.

All this – this excess of images together with the fear of spending a fortune on a prism – is proof, in our view, of the affectivity by which this writer's unconscious is weighed down as he struggles against Newtonian mathematism.

However, having shown the will to remain within *physical* experience

in order to explain *physical science*, let us see how a pre-scientific mind will oppose the giving of mathematical form. Father Castel reacts against the theory of attraction especially. In his view, Newton 'had given himself over to Geometry too abruptly. He was sparing of forms, for he scarcely conceived of any differences in bodies other than matter itself, density, and weight, and he was consequently as sparing of matter as Descartes was prodigal with it. (He has) immaterialised the celestial spaces'. This first attempt by Newton to give physics a mathematical form is therefore reproached with being *abstract*, as though this were a prior objection. Newton the mathematician is showered with compliments so as to condemn him all the more effectively as a physicist. 'The system (Newton) presents in his third book (of the *Principia*) as a system of Physics is in fact entirely mathematical', Castel writes. 'This incontestably secures for it the name of Physico-mathematical. It remains to be known whether a truly Physico-mathematical system can be regarded as a true Physical system'.[21]

This is not of course an isolated criticism, but more of a leitmotif in the eighteenth century. There was at that time a real wish to drive mathematics out of physics. For very many writers, mathematics in no way explains phenomena. De Marivetz calmly writes without further commentary that 'The phrase *to calculate a phenomenon* is very incorrect; it was introduced into Physics by those who were better at *calculating* than *explaining*'. We only need to lay just a little more emphasis on the words in this statement with regard to the role of mathematics in physics and we have the now oft-repeated epistemological theory according to which mathematics *expresses* but does not *explain*. Contrary to this theory, we ourselves believe that mathematical thought forms the basis of physical explanation and that the conditions of abstract thought are from now on inseparable from those of scientific experiment.

Moreover, many of those opposed to the giving of precise mathematical form make use of geometrical terms in spite this. They even use them in an incredibly free and easy manner. Carra, for instance, believes that comets describe 'a spiral parabola' and explains his astronomical system in these terms:

> In my theory, the first projecting movement of all celestial bodies is a line that forms a parabola; this parabola becomes a spiral; this spiral conforms to an ellipse, and the ellipse to a circle; the circle once more becomes an ellipse; the ellipse again becomes a parabola, and the parabola a hyperbola. This graduated change from simple to compound curves and from compound curves to simple ones explains not just changes but the mutation

of the polar axes, their increasing and decreasing inclination, and the obliquity of the equators.

We could produce endless examples of this kind of geometrical mish-mash. This one example will suffice though to show the seductive charms of geometrical images that are put forward as a group, without any constituting principles being offered in order to justify these images, and – for a very good reason! – without the transformation being provided that would allow us to pass from one curve to another, from ellipse to hyperbola. A sound and healthy mathematical conception, such as that achieved in Newton's system, will on the contrary allow different geometrical instances to be envisaged, while leaving some play – a well-defined play, however – for empirical applications. Newton's system gives a scheme of possibilities, a coherent pluralism of quantity that permits the conception of orbits which are not just elliptical but also parabolic and hyperbolic. The quantitative conditions for their application are well-defined; they form a scheme that can unite electrical attraction and repulsion in one general view.

From this single example in which the activity of imagination and the activity of reason are compared, we can sense the need for the algebraic explanation, the indirect, discursive explanation therefore, of the geometrical forms that intuition finds much too beguiling.

Moreover, the unconscious valorisation of simple geometrical forms could quite easily be seen in both history and teaching. Thus, as long as you restrict yourself to general statements of Kepler's laws, you can be pretty sure of being misunderstood. This is because for the pre-scientific mind the ellipses described by the planets are thought in terms of the circle, which remains the pure form, the natural, valorised form. For the pre-scientific mind, the ellipse is a badly-made circle, a flattened circle, or as one eighteenth-century writer puts it, in a phrase that makes the valorisation very clear, the ellipse is a circle that is *regaining its health.* For this kind of intuition, the ellipse is already a perturbation and is the result of a real *accident*. This conception is especially clear in Nicolas Hartsoeker's system. In a book entitled *Conjectures physiques*, published in 1706, Hartsoeker links the ellipticity of the terrestrial orbit to *terrestrial* upheavals similar to the earthquake of 18 September 1692. These earthquakes cause settling and compression, increasing the earth's density; the earth *falls* then towards the sun since it has become heavier; as it descends, it loses some of its velocity, doubtless because of its incorporation into an inner vortex (?).[22] It then remains stationary for a moment, and afterwards re-ascends to the place from which it had started, without it being possible to see from Hartsoeker's long exposition how and

why the earth returns to its first place. Anyway, since the cataclysm brought about a coming together followed by a distancing, we now have two different radiuses: in Hartsoeker's view, this suffices to explain the ellipticity of the orbit. In any case, Hartsoeker does not feel the need for proof here. He regards ellipticity as being initially an *accident*. He will therefore direct his greatest endeavours to finding the proof of *such accidents*. He does not look far for the proofs he needs, studying the complexity of geological strata. Thus, without making any transition, he goes on to describe the different layers of earth encountered during the sinking of a well 232 feet deep, going from clay to sand, sand to clay, and then again from clay to sand... All these material contradictions could only have been caused by accidents. These material accidents gave rise to astronomical accidents. What is ill-made in the heavens is the result of what is ill-made on earth.

These primary images of naive topology are very frequently found. They are therefore ways of understanding to which people endlessly resort. This constant use makes them increasingly clear and explanatory, hence the valorisation we are indicting. Thus, for a non-scientific mind everything round is a circle. When an intuitive characteristic is given this kind of increased value, real errors come to be made. Voltaire for example calmly comes out with this outrageous statement: 'A circle that is changed into an oval neither increases nor decreases in area'.[23] He imagines that it is the area a curve encloses that measures the full reality of that curve: a line that closes on itself does so in order to enclose a reality, making it a possession.

It is not impossible to find even more heavily laden intuitions. For animist intuition – and this can be noted fairly frequently – every oval is an egg. One author explains this irrational idea in pretty clear terms. Writing in 1787, Delairas claims he has found a synthetic theory of generation. In his opinion, this generation takes place in accordance with a uniform principle; particular circumstances only bring diversity to the application of that principle. He consequently proposes to study the principles of generation 'in relation to the most considerable of organised beings, where nature develops on a grand scale the dispositions it follows and appears to conceal from us in beings that are less compound and of smaller volume'. He undertakes to shed light on the problem of the generation of animals by means of that of the stars. Only a minimum of geometry is needed here. Does not the astronomical fluid of a star take an oval, egg-shaped form? Now, 'all generation takes place by means of eggs, *cuncta ex ovo*,[24] that is to say by means of an oval'. That is the essence of the proof, and the whole proof in fact. A kind of animist generalisation can be seen here in all its puerility, in all its striking geometrical dryness. What is more, does not a philosophical view that rests

on a 'deep' intuition, on an avowed communion with universal life, share the same riches and the same resources as Delairas's astronomical egg? In any case, geometrical representation makes this absurdity all the more obvious, and only a heavily burdened unconscious could produce this kind of animist generalisation.

If we are to break with all these attractions of simple, complete forms around which so many erroneous interpretations can gather, then the best thing we can do is to make the algebra explicit here. For example, the scientific teaching of planetary motion must not be content to repeat that the planets describe ellipses round the sun, which occupies one of their two foci; this teaching must use discursive calculation to link the algebraic reality of attraction to the phenomenon of Kepler's motion. It would no doubt be easier just to *teach the result*. Yet teaching the *results* of science is never teaching of a truly scientific kind. If we do not explain the mental route leading to the result, then we can be sure that pupils will combine the result with their most familiar images. Pupils have indeed to 'understand'. You can remember only if you understand. But pupils understand in their own way. Since they have not been given any reasons, they attach their own personal reasons to the result. It would be fairly easy for a physics teacher with some insight into psychology to see how, in relation to the present problem, an unexplained intuition 'matures'. Thus, after a few weeks, when the verbal memory of the lesson has been replaced by what Pierre Janet has so aptly described as a memory that has been worked on,[25] it is quite common to find that the sun has moved: it no longer occupies a *focus* of the ellipse but is at its *centre*. In the teaching of results, what indeed is the focus of an ellipse? Why speak of one focus rather than the other? If one focus is *reified* by the sun, why is the other one forsaken? When the correct result is kept in the memory, it is often thanks to the construction of a whole framework of error. The key to the problem is the word 'focus', or rather its etymology: in Latin, *focus* means a fireplace, a domestic hearth, and while the English word has lost touch with its roots the French word *foyer* has not, being used to mean a fireplace, a home, and also a focus in an ellipse. The sun gives heat and light to the entire universe and so is obviously a *foyer* for a French speaker. Were a different word used in French with regard to ellipses – a neutral, mathematical word – then French schoolchildren preparing for the baccalaureate would have found it harder to state Kepler's laws and would have made far more formal errors. The following phrase used by the Comte de La Cépède is very symptomatic here in its geometrical indetermination and also in the need he feels for a pompous adverb: 'The Sun ... gloriously occupies one of the foci (*foyers*, in French) of the revolutions of our comets and our planets'. However in teach-

ing physics, I myself have come across more fallacious 'rationalisations' than this simple linguistic one. On one occasion, an intelligent pupil gave me this answer: the sun is at the focus of the terrestrial ellipse because if it were at the centre, there would be two summers and two winters in one year. Based as it is on total ignorance of the way the plane of the ecliptic is influenced by the inclination of the terrestrial axis, this objection is psychologically instructive. It shows us an ingenious mind giving weight to an all-embracing, image-laden representation. The mind is seeking to link all it knows to a central, primary image. All phenomena have to be explained by the main piece of knowledge. This is the law of least effort.

If physics teachers undertook more psychological investigations, they would be surprised at the variety of individual 'rationalisations' for one and the same item of objective knowledge. All they have to do is wait until a few weeks have passed after the lesson and they will observe this individualisation of objective culture. It seems in fact that too clear an image, an image that is seized upon too easily and too speedily, then attracts a whole host of false reasons as the slow process of individualisation takes place. Teachers would be well advised to put a stop to subjective proliferations by frequently returning to objective topics. This would mean what we will call *recurrent teaching*, a kind of teaching that is singularly neglected in our secondary schools but that we consider indispensable to the strengthening of objective culture.

The history of science, that inexhaustible mine of reasoned errors, could of course provide us with many examples of this supremacy of the resultant image over the calculation that ought to explain it. On the very precise point of the ellipticity of planetary orbits deduced by correctly calculating attraction in inverse ratio to the square of the distances, we are struck by Father Castel's very realistic objections because they concur with the pedagogical observations we have been able to make. They are as follows:

> If it had ... to be decided which of the two had priority, it would be incontestably more natural to deduce the Ratio I/D^2 from Ellipticity than Ellipticity from the Ratio I/D^2. Ellipticity is better known than this Ratio is. It is given to us by the immediate observation of celestial motion, and is a perceptible fact and one that is purely physical. On the other hand, the Ratio I/D^2 is a matter of Geometry, of a Geometry that is deep and subtle, and in a word Newtonian.[26]

This last remark is intended by Castel to express the strongest criti-

cism. It is however a remark that very soon backfires on him. Castel did not want to follow Newton's *mathematical realisation* of attraction. He himself comes to make declarations that are both general and vague, and that have no currency in the scientific community, as for instance when he states that 'everything happens by contranitescence'. There is nothing more *individualised* that Father Castel's astronomy. By accumulating errors, he managed to take the objective knowledge summarised in Newton's system and think it subjectively.

We can moreover attempt to combat the valorisation of everyday geometrical images directly by trying to link them to families of more general images. A mathematical mind that understands the ellipse to be a particular instance of curves of the second degree is certainly far less in thrall to the realisation of a particular image. Experiments with electricity have brought us face to face with repulsive forces and given us a real and important example of hyperbolic trajectories, as in Rutherford's experiment on the deviation of alpha particles through a thin plate, and have thus contributed towards the healthy generalisation of Newtonian principles. Here, objective generalisation is an escape from individual images. In addition, we cannot recommend too strongly that *inversions* of the order of construction should be introduced right from the first for even the most junior pupils in our secondary schools. The problem of Newtonian astronomy is only truly mastered when you can alternately derive the law from the empirical form and reconstruct the pure form from the law. Only then does the problem of perturbations have any meaning. This remark is a very obvious one and is certainly not new, but its full importance only emerges when it is seen from a psychological standpoint, as an encouragement to make increasing use of the psychological exercise of reciprocal analysis and synthesis. These two-way exercises will prevent the mind from settling down happily into its preferred activity, an activity which will soon be valorised; they will, in particular, correct the tendency to intellectual repose to which the use of intuition leads, and so the habit of discursive thought will develop. Indeed, we have often made useful attempts to convert values simply with reference to images. For example, we used to develop the following antithesis in our classes. For Aristotelian science, the ellipse is an ill-made circle, a circle that has been flattened out. For Newtonian science, the circle is an impoverished ellipse, an ellipse whose foci have been flattened down on top of each other. I would then champion the ellipse's cause: the centre of the ellipse is of no use since it has two distinct foci; for the circle, the law of areas is banal whereas for the ellipse, it is a discovery. I would gradually try to sever, very gently, the mind's attachment to privileged images. I would guide it into the paths of abstraction,

trying hard to give pupils a taste for abstraction. In short, it seems to me that where the intellect is concerned the first principle of scientific education is this asceticism of abstract thought. This alone will allow us to master experimental knowledge. I therefore have little hesitation in presenting rigour as the psychoanalysis of intuition, and algebraic thought as the psychoanalysis of geometrical thought. Even in the realm of the exact sciences, our imagination is a sublimation. Though useful, it can deceive us as long as we do not know what and how we are sublimating. It is of value only insofar as its principle has been psychoanalysed. Intuition must never be a given: it must always be an illustration. Our final chapter will show, in as general a manner as possible, the need for a psychoanalysis of objective knowledge.

NOTES

1 Bachelard's footnote: Paul Mouy, *Le Développement de la physique cartésienne, 1646-1712* (Paris: 1934), 144.

2 This refers to a section in Bachelard's *Essai sur la connaissance approchée* (Paris: Vrin, 1928), 166-67.

3 Bachelard's footnote: G. Cuvier, *Histoire des sciences naturelles*; see Chapter 8, note 5.

4 Bachelard's footnote: Jacques-Henri Bernardin de Saint-Pierre, *Études de la nature*, 4th ed., 4 vols. (Paris: 1791).

5 Bachelard's footnote: Madame du Châtelet, *Dissertation sur la nature et la propagation du feu* (Paris: 1744).

6 This would seem to refer to Bachelard's complementary doctoral thesis of 1927, published as *Étude sur évolution d'un problème de physique: la propagation thermique dans les solides* (Paris: Vrin, 1928); this book examines the history of the problem of heat transfer in solids.

7 Bachelard's footnote: Martine, *Dissertation sur la chaleur avec les observations nouvelles sur la construction et la comparaison des thermomètres*, trans. (Paris: 1751).

8 Bachelard's footnote: Retz, Physician in Paris, *Fragments sur l'électricité du corps humain* (Amsterdam: 1785).

9 Pascal's phrase 'l'esprit de finesse' is again used here; see Chapter 7, note 25.

10 Bachelard's footnote: Wilhem Ostwald, *Énergie*, trans. (Paris: Alcan, 1924), 10.

11 'Prince Rupert's drop' was a tadpole-shaped piece of solid glass, formed in the way Bachelard describes, which resulted in the thick end being very resistant and the thin end being weak; if the thin end was broken off or scratched, the whole drop exploded – harmlessly – into fine powder. It was named after Prince Rupert of Bavaria who introduced it into England in the 1640s. Although intended to illustrate stress in glass, it gained fame through being used as a joke by Charles II (Prince

Rupert's uncle) who would ask someone to break off the glass tip and then enjoy their reaction to the harmless explosion.

12 Bachelard's footnote: Joseph Bertrand, *Histoire de l'Académie des Sciences*.

13 Jules Michelet, *L'Insecte* (Paris: 1858).

14 Bachelard's footnote: Hans Reichenbach, *La Philosophie scientifique*, 16.

15 Bachelard's footnote: Anonymous, *Essai de Physique en forme de lettres* (Paris: 1768).

16 Bachelard's footnote: Abbé Pluche, *Histoire du Ciel*, new ed. (Paris: 1778).

17 Bachelard's footnote: Jean-Paul Marat, *Mémoires académiques ou nouvelles découvertes sur la lumière, relatives aux points les plus importants de l'optique* (Paris: 1788). Bachelard's reference at the beginning of section VII to Marat's 'gentle period' is a reminder of Marat's violent role as a leader in the 1789 Revolution.

18 Bachelard's footnote: Rev. Father Louis Castel, *Le Vrai système de Physique générale de Newton, exposé et analysé avec celui de Descartes; à la portée du commun des Physiciens* (Paris: 1743).

19 Bachelard's footnote: Rev. Father Louis Castel, *L'Optique des couleurs* (Paris: 1740).

20 The French word *spectre* used here means both 'spectrum' and 'spectre'; the adjective 'spectral' is appropriate to both senses and has been chosen for this reason.

21 See note 18.

22 The question mark here is Bachelard's.

23 Bachelard's footnote: Voltaire, *Oeuvres complètes*, vol. 41 (Paris: 1828).

24 'Everything from an egg', i.e. 'all life comes from an egg'.

25 Bachelard discusses Janet's conception of the work of memory in *The Dialectic of Duration*, Chapter 2, where he draws extensively on Pierre Janet's *L'Évolution de la mémoire et de la notion du temps* (Paris: Chahine, 1928).

26 See note 18.

Chapter Twelve

Scientific objectivity and psychoanalysis

I

In the foregoing chapters, we have whenever possible included brief statements indicating how in our view the scientific mind overcomes the different epistemological obstacles and constitutes itself as rectified errors. However, these scattered statements are doubtless far from providing a complete theory of the objective attitude. And a set of truths that have been won by defeating disparate errors may not seem to offer the kind of very smooth and homogeneous domain of truth that gives scientists the joy of possessing something tangible and sure. Scientists are in fact increasingly less eager for these all-embracing joys. They have often been said to be becoming more and more specialised. Philosophers, those specialists in generalities, have put themselves forward to make syntheses. The fact is though that scientists come to wish for and to seek synthesis because of their speciality. They cannot regard as objective any thought that they themselves have not objectified. Consequently, someone concerned with psychology rather than with philosophy will, in our view, always have to come back to the standpoint that has been ours in this book: psychologically speaking, there is no truth unless an error has been rectified. A psychology of the objective attitude is a history of our own personal errors.

By way of conclusion, however, we wish to attempt to bring together the general elements of a theory of the knowledge of objects.

We shall once again open our discussion with a polemic. In our opinion, the following postulate must be accepted in epistemology: the object cannot be designated as an immediate 'objective'; in other words, movement towards an object is not initially objective. It must therefore be accepted that there is a very real break between sensory knowledge and scientific knowledge. Indeed, we believe that in our critiques here we have shown that the

normal tendencies of sensory knowledge, with all their immediate pragmatism and realism, only lead to a false start and to a wrong direction being taken. In particular, immediate adherence to a concrete object, which is held like a possession and used like a value, involves sentient beings too greatly: it is *inward satisfaction*, not *rational evidence*. As Baldwin's admirably dense phrase puts it: '*It is stimulation* and not response that is the controlling factor in the construction of objects of sense'.[1] Indeed, it is in the form of *stimulation* that the *first objectivity* continues to be understood, even by the sated, thoroughly gratified being who believes the time for thinking freely is at hand, and even when that form is an apparently general one. This need to feel or sense objects, this appetite for objects, and this indeterminate curiosity in no way correspond to a scientific state of mind. Just as a landscape is called a romantic emotional state – an inner state of mind and spirit – so in the same way a piece of gold can be called a miser's emotional or inner state, and light an ecstatic one. When you try to put a pre-scientific mind on the spot by raising objections to its *initial* realism and its claim to lay hold of its object straightaway, it will always reveal the psychology of that *stimulation* which is the truly convincing value, without ever coming systematically to the point where there is the psychology of objective control. In fact, as Baldwin sees, this control is initially the result of *resistance*. Generally speaking, control is understood as 'the checking, limiting, (and) regulation of the constructive processes'.[2] It is hard to find an equivalent French word for the English concept of *checking*, but it can be usefully linked to a similar sounding word in French, *échec*. *Échec* means failure, not checking, so how can we say they are linked? Failure is in fact a prerequisite of the checking of stimulation. Were there no failure, stimulation would be *pure value*. It would be thrilling and intoxicating and therefore a huge subjective success, which would make it the most unrectifiable of objective errors. Thus, those who have the impression that they *never* make mistakes are, in our view, always mistaken.

It will be objected that this first rush of enthusiasm has been rather too quickly reduced and that errors made when trying things out are in fact eliminated by behaviour. Scientific knowledge could therefore be seen as resting on sensory knowledge that behaviour has made coherent. We do not accept this kind of conciliation however, for the stimulation's original impurity has not been amended by *reprimands* – another sort of checking – from the object. There are still *values* attached to the first objects. Sensory knowledge remains a faulty compromise.

If we are to be quite sure that stimulation is not at the root of our objectification and that objective control *reforms* rather than echoes, then *social control* has to be brought in. At the risk of being accused of going in a

vicious circle, we propose that objectivity be based on the behaviour of other people. Putting it another way so as to make our paradoxical turn of thought abundantly clear, we wish to choose other people's eyes – always the eyes of others – to see the form – the well and truly abstract form – of the objective phenomenon: tell me what you see and I'll tell you what it is. Only by this rather circuitous and apparently nonsensical route can we be sure of having totally disregarded our first perceptions. We are doubtless well aware of all we shall be losing. At one go, the colour goes out of the world, our food is deodorised, and all our natural psychic momentum is broken, reversed, misunderstood and despondent. We so needed to be whole and complete in our vision of the world! Yet it is precisely this need that must be overcome. So let's get going! It is not in the full light of day but rather where shadows begin that a beam of light diffracts and tells us its secrets.

Moreover it must be noted that every theory of objectivity always comes to place the knowledge of objects under other people's control. Usually though we wait until a solitary mind's objective construction has been completed before judging it in its final aspect. We therefore leave the solitary mind to get on with its work, without keeping any check on either the cohesion of its materials or the coherence of its proposals. We are suggesting that there should on the contrary be a preliminary doubt affecting at one and the same time facts and their connections, experiment and logic. If our thesis seems artificial and pointless it is because people do not realise that modern science is working with experimental materials and logical frameworks that have long been socialised and that are consequently already controlled. Our intention though is to determine the initial conditions of objective knowledge and we must therefore study the mind at that moment when, of itself, solitary and facing nature in all its vastness, it claims to be designating *its own* object. This first designation has, we believe, been proved incorrect when in a previous chapter we looked at the beginnings of electrical science. We need only observe young experimenters too as they strive, without any helping hand, to make an experiment precise and we shall recognise that the first *exacting* experiment is the one that 'goes all wrong'. *All precise measurement is prepared measurement*. The order of increasing precision is an order of increasing instrumentalisation, and therefore of increasing socialisation. Landry said that 'It is an easy matter to move an object lying on a table by a centimetre; moving it by a millimetre requires the complex interplay of antagonist muscles and is much more tiring'. In fact this last delicate measurement requires the *checking* of stimulation and is won only after failed attempts at it, in the discursive objectivity whose principles we are trying to elucidate here. However, moving an object lying on a table by a millimetre is not yet a scientific

operation. Scientific operations start at the next decimal point. To move an object by a tenth of a millimetre you need a piece of apparatus and therefore a body of professionals who can make it. If you finally get to the next decimal points, aiming for example to find the width of an interference fringe and determine, by closely related measurements, the wavelength of a particular type of radiation, you then need not just apparatus and bodies of apparatus-makers but also a theory and therefore a body of scientists, an Academy of Science in fact. A measuring instrument always ends up as a theory: the microscope has to be understood as extending the mind rather than the eye.[3] Thus, discursive and social precision shatters the inadequacies of what is intuitive and personal. The more delicate the measurement, the more indirect it is. Science done in solitude is qualitative. Socialised science is quantitative. When the duality of mind and universe is examined in terms of an attempt to acquire personal knowledge, it emerges as the duality of an ill-prepared phenomenon and an unrectified sensation. When the same fundamental duality is examined in terms of an attempt to acquire scientific knowledge, it emerges as the duality of apparatus and theory, a duality that is no longer oppositional but reciprocal.

II

We shall come back to the process of discursive rectification that seems to us the fundamental process of objective knowledge. Before doing so, we wish to draw attention to some of the social aspects involved in teaching the objective attitude that characterises modern science. Since there is no objective process without consciousness of a first, inward error, we have to begin our lessons in objectivity with a real confession of our intellectual sins. Let us therefore confess our foolish ways so that our brothers and sisters can see their own follies in ours, and let us ask them to make the same confession and render us the same service. Let us interpret in terms of intellectuality the following lines commented upon by psychoanalysis:

> Selten habt Ihr mich verstanden
> Selten auch verstand ich Euch
> Nur wenn wir in Kot uns fanden
> So verstanden wir uns gleich![4]

Together let us break with the pride of general certainties, with the cupidity of particular certainties. Let us prepare ourselves and each other for the intellectual asceticism that puts an end to all intuitions, that slows down

every prelude, and defends itself against intellectual presentiments. And let us in our turn, in our wholehearted devotion to the intellectual life, utter these words: you, error, are not an evil. Enriques expressed this very well when he wrote that 'If we reduce error to the distraction of a tired mind, we are only thinking in terms of book-keepers totting up figures. There is a much wider field to be explored when we are dealing with real intellectual work'.[5] This is when we get to positive error, to error that is both normal and useful. And with a theory of normal error as our guide, we learn to distinguish between what Enriques calls 'the faults for which reasons can quite properly be sought and those that are not really errors but rather gratuitous affirmations, made without any effort of thought by charlatans who rely on getting lucky breaks for quick guesswork; understanding has nothing at all to do with the latter'. The sequence of *common*, *normal* errors must therefore be arranged along a line of objectivity. The full import of a psychoanalysis of knowledge would then be felt if we could just extend this psychoanalysis a little further. We cannot really perform this preliminary catharsis on our own and it is every bit as difficult to begin this process as it is to psychoanalyse oneself. We have been able to determine only three or four major sources of error for objective knowledge. We have seen the dialectic of the real and the general to have echoes in the psychoanalytical themes of avarice and pride. It is not enough though to cut the mind free from these two perilous places. It has to be led to finer and finer abstractions, by driving out more and more fallacious faults. This sensitive, subtle teaching would require complex scientific societies, scientific societies in which logical endeavours are accompanied by psychological ones.

Clear progress has in fact been made here. Modern society professes – in its administrators' declarations at least – the educational value of science and it has developed qualities of objectivity to a far greater extent than science could do in periods when fewer people had any schooling. Boerhaave noted that the reason for chemistry being so long incorrect in its very principles lay in the fact that it was long a solitary kind of culture. This observation was made as he began, with much difficulty, his treatise on chemistry. He regarded chemistry as a difficult science to teach. Contrary to what might be thought, the *chemical object*, substantial as it is, is not easily designated in the early days of science. On the other hand however, as science becomes more social, that is to say easier to teach, it becomes better at conquering its objective bases.

We must not exaggerate though the value of formal education. In fact as Von Monakov and Mourgue observe, relationships with the peer group are more formative for schoolchildren than their relationships with older people,

and classmates are more important than teachers. Teachers provide ephemeral, haphazard knowledge, especially in the incoherent multiplicity of secondary-school teaching, knowledge which also bears the pernicious stamp of authority. On the contrary, our schoolmates implant indestructible instincts in us. We ought therefore to take a group of pupils and encourage them towards consciousness of a group reason. In other words, we should help them acquire the instinct for social objectivity, for this is an instinct that is underestimated and in whose place we prefer to develop the opposite instinct of *originality*, failing to see the contrived and artificial character of the originality we learn about from our literary studies. To put it another way, if objective science is to be really educational, then the way it is taught must be socially active. Normal educational practice makes a big mistake when it establishes an inflexible relationship between teacher and pupil. In our view, the fundamental principle of the *pedagogy* of the objective attitude is this: *whoever is taught must teach.* Any teaching that is received and not then passed on to others will form minds devoid of any dynamism and self-criticism. In science subjects especially, this kind of teaching makes knowledge fixed and dogmatic, whereas this very knowledge ought to be a spur to further progress and invention. Most important of all, it fails to provide the psychological experience of human error. I can imagine only one admissible use for the school tests by which pupils are ranked and that is as a means of choosing instructors who would pass on a whole range of lessons, gradually decreasing in rigour. The pupil who comes top would be rewarded by the pleasure of teaching the second to top, who would then teach the pupil in third place, and so it would continue until the errors really did become too sizeable. The tail end of the class is not, we may add, without its usefulness for psychologists, for it exemplifies the non-scientific species, the subjectivist species, whose immutability is highly instructive. The rather inhumane way in which the dunce is used in many a mathematics class can be forgiven if we remember that those who are objectively in the wrong put themselves subjectively in the right. Members of the cultured middle classes think it rather smart to boast of their total ignorance where mathematics is concerned. People will really wallow in their failure, once that failure is sufficiently plain. The existence of a group that is immune to scientific knowledge encourages us in any case to psychoanalyse rational convictions. It is by no means enough for people to be right: they have to be right *against* someone else. If this *social* dimension is lacking in the exercise of rational conviction, then our sense of being profoundly in the right is not far from being a feeling of resentment; any conviction that is not put to the test by our efforts to teach it to someone else will act in our soul like an unrequited love. Indeed, what proves

the psychological healthiness of modern science as compared with the science of the eighteenth century is that there is now a steady decrease in the number of things that are *misunderstood*.

The best proof that this progressive pedagogy corresponds to the psychological reality of adolescents is to be found in the theory of *bilateral play* briefly outlined by Von Monakow and Mourgue as follows:

> When we studied *the instinct of self-preservation*, we stressed the need to take precedence that is observed when children are playing. However, there is another aspect of children's games that ought to be brought to light. Children do not in fact seek to assert themselves *invariably*; having played at being generals they are then perfectly happy to be foot soldiers. Were this not the case, the function of play – which is preparation for social life – would be distorted and, as is in fact the case with unsociable children, anyone who resists the more or less implicit rules of the game would be eliminated from the small group the children form.[6]

The teaching of experimental and mathematical subjects would gain by fulfilling this fundamental condition of play.

If we have allowed ourselves to describe, though briefly, this utopia of the schoolroom, it is because it seems to offer us, relatively speaking, a practical and tangible way of measuring the psychological duality of rational and empirical attitudes. We believe in fact that there is always an interplay of philosophical nuances in any real, living teaching: *the teaching we receive is, psychologically speaking, a kind of empiricism; the teaching we give is, psychologically speaking, a kind of rationalism*. When I listen to you, I am all ears. When I talk to you, I am all mind. Even if we are both saying the same thing, what you say is always somewhat irrational; what I say is always somewhat rational. You are always slightly in the wrong and I am always slightly in the right. What is being taught is of little importance. It is the psychological *attitude*, composed of resistance and incomprehension on the one hand and of impulse and authority on the other, that comes to be the decisive factor in any real teaching, when books are left behind and we talk instead to other people.

Now, since objective knowledge is never complete and since new *objects* never cease to provide new topics of conversation in the dialogue between the mind and things, any real, living teaching of science will be drawn this way and that by the ebb and flow of empiricism and rationalism. Indeed, the history of scientific knowledge is an endlessly renewed alternation of empiricism and rationalism. This alternation is more than just a fact. It is a

necessity for our psychological dynamism. This is why any philosophy that confines culture to either realism or nominalism sets up the most formidable obstacles to the development of scientific thought.

In a splendid extemporisation at a recent congress of philosophers, Lalande has suggested that in order to cast light on the interminable polemic of rationalism and empiricism, a systematic study should be made of the periods in which reason finds great satisfaction and of those in which reason is ill at ease. He showed that in the course of the development of science, syntheses suddenly occur that seem to swallow up empiricism, like for instance Newton's synthesis of mechanics and astronomy, Fresnel's of vibration and light, and Maxwell's of optics and electricity. At such times, teachers are triumphant. Yet then the brightness fades and darkness gathers; something is going wrong, for Mercury stirs in the heavens, photoelectric phenomena fragment the wave, and fields cannot be quantified. At such times, doubters are wreathed in smiles, like schoolchildren. Were we to extend the study Lalande has suggested, we would be able to determine in a precise way what exactly is meant by the *satisfaction* of reason when it rationalises a fact. We would then see, as accurately as possible and with respect to specific instances in the sure domain of past history, the passage from the assertoric to the apodeictic and the illustration of the apodeictic by the assertoric.

Yet while this purely historical study will provide us with the quasi-logical meaning of the satisfaction of reason, it cannot offer us the psychology of *the feeling of being in the right*, in all its complexity and in the ambivalence here of gentleness and authority. If we are to know all the emotions involved in the use of reason, we shall have to live and teach a scientific culture, we shall have to defend it against all irony and incomprehension, and then arm ourselves with it and sally forth against philosophers, against psychologists of the inner life, against pragmatists and realists alike. We shall then have some idea of the range of values associated with the rational emotion: when it is people who put us in the right with regard to other people, we taste the sweet success beloved of politicians with their will to power. When however it is things that put us in the right with regard to other people, we witness the triumphant success not of the will to power but of the will to be rational in all its brilliancy, *der Wille zur Vernunft*.

However, things can never put the mind in the right once and for all. It is moreover very certain that this rational satisfaction must be renewed if it is to provide real psychic dynamism. Through a curious effect of habituation, the apodeictic, now grown old, acquires a taste for the assertoric and the *rational fact* remains, without the rational system. The only thing people remember about the whole of Newton's mechanics is that it was the study of

attraction, whereas for Newton himself attraction was a metaphor, not a fact. It has been forgotten that Newtonian mechanics assimilated apodeictically the *parabola* of the movement of projectiles on earth and the *ellipse* of planetary orbits, thanks to a rational system. We must therefore take steps to prevent rational truths from degenerating, for they always tend to lose their apodeicticity and deteriorate into intellectual habits. Balzac said that bachelors and old maids put habit in the place of emotion. In exactly the same way, teachers put lessons in the place of discovery. Teaching about the discoveries that have been made throughout the history of science is an excellent way of combating the intellectual sloth that will slowly stifle our sense of mental newness. If children are to learn to invent, it is desirable that they should be given the feeling that they themselves could have made discoveries.

We must also disrupt the habits of objective knowledge and make reason *uneasy*. This is indeed part of normal pedagogical practice. It is not without a touch of sadism, which shows us fairly clearly the presence of the will to power in science teachers. This teasing use of reason operates in the reverse direction too. In our ordinary day-to-day-lives in fact, we love putting someone else in a spot. The person who sets riddles provides us with a revealing example here. Often, a riddle that comes out of the blue is the revenge of the weak against the strong, of pupil against teacher. When children set their fathers a riddle, in all the ambiguous innocence of intellectual activity, are they not satisfying their Oedipus complex? And vice versa, it is not hard to psychoanalyse the attitude of the mathematics teacher, serious and awesome as the sphinx.

We can also discern in certain educated minds a real intellectual masochism. They need some kind of mystery behind the clearest solutions in science. They are reluctant to accept the clear, self-conscious evidence furnished by axiomatic thought. Even when they have conquered and mastered a mathematical concept, they still need to postulate some kind of realism that lies beyond their grasp, crushing them. In the physical sciences, they postulate reality's fundamental irrationalism, whereas in fact where laboratory phenomena are concerned, thoroughly mastered and mathematised as these phenomena are, this irrationalism is just the *result of all the carelessness* perpetrated by the experimenter. Yet the mind does not seek the quiet enjoyment of knowledge that is completely closed in on itself. It does not think of present difficulties but of those of tomorrow; it does not think of the phenomenon securely imprisoned in the apparatus now in use, but rather of the phenomenon that is free and untamed, impure and hardly even named. Philosophers turn this unnamed thing into the unnameable. Brunschvicg has recognised

that this duality, marked as it is by contrary valorisations, is present even in the foundations of arithmetic, for he has spoken of a science of number which is used either to prove or to impress and dazzle, meaning of course that before we dazzle others, we must first blind ourselves.[7]

Yet these sadistic or masochistic tendencies, which are particularly apparent in the social life of science, do not provide an adequate description of the real attitude of the lone scientist; they are no more than the first obstacles scientists must surmount in order to acquire complete scientific objectivity. In the present state of scientific development, scientists face the continuing need to *renounce their own intellectuality*. If there is no explicit renunciation, no relinquishment of intuition, and no abrogation of favourite images, then objective research will soon lose not just its fruitfulness but the very vector of discovery, the inductive impetus. We must constantly strive towards desubjectification if we are to live and relive the instant of objectivity, if we are to remain forever in the *nascent state* of objectification. The mind that psychoanalysis has freed from the twofold slavery of subject and object can savour the heady delight of oscillating between extraversion and introversion. An objective discovery is at once a subjective rectification. If the object teaches me, then it modifies me. I ask that the chief benefit the object brings should be an intellectual modification. Once pragmatism has been successfully psychoanalysed, I wish to know for the sake of knowing, never for the sake of *using*. Conversely too, if through my own efforts I have been able to obtain some psychological modification – which can only be imagined as a complication at the mathematical level – then fortified by this essential modification, I go back to the object, I call upon experiment and technique to illustrate and bring about the modification that has already been brought into being psychologically. The world will doubtless often resist, the world will always resist, and the efforts of mathematics must be ever renewed, they must grow ever more flexible and must be constantly rectified. But as they are rectified, so they are enriched. Suddenly, the efforts of mathematics are so successful that reality crystallises along the axes provided by human thought and new phenomena are produced. Indeed, we can now speak without any hesitation of the creation of phenomena by humankind. The electron existed before twentieth-century men and women. But before them, the electron did not sing. In the triode valve however, the electron sings. This phenomenological *realisation* occurred at a precise point when mathematical and technical development was coming to maturity. Any attempt at a premature realisation would have been in vain. Had astronomy sought to *realise* the music of the spheres, it would have failed. It was but a meagre dream that gave a meagre science value. The music of the electron in an

alternating field has, on the other hand, proved to be realisable. This dumb being has given us the telephone. This same invisible being will give us television. Thus, humankind triumphs over the contradictions of immediate knowledge. We force contradictory qualities to become consubstantial as soon as we have freed ourselves of the myth of substantialisation. There is no longer any irrationalism in a substance that organic chemistry has made with great care and attention: irrationalism could only be an impurity. Such an impurity can moreover be tolerated. The moment it is tolerated, we see that it is quite powerless and in no way dangerous. Functionally speaking, this impurity does not exist. Functionally speaking, a substance realised by modern chemical synthesis is entirely rational.

III

It is doubtless true that just when science requires the most far-reaching psychological mutations, interests and instincts show themselves to be curiously stable. Classical psychologists then have an easy victory over our adventurous views. With all their bitter wisdom,[8] they remind us that it takes more than an equation to change the human heart and that a few hours of wondrous intellectual ecstasy are not enough to reduce instincts and give rise to new organic functions. Despite such criticism, we steadfastly believe that, in the exclusive form in which some spirits live it, scientific thought is psychologically formative. As Julien Pacotte has pointed out in a penetrating article, 'in biological evolution, the living being's sudden orientation towards the environment in order to organise it in a way that is independent of its body is indeed an incomparable event ... Technique is an extension of biology'.[9] But now we see abstract, mathematical thought extending technique, and scientific thought reforming phenomenological thought. Modern science is increasingly a reflection on reflection. To show the revolutionary character of this complexity, we could look again at all the themes of biological evolution and study them simply from the standpoint of the relations of the internal to the external. We would see that, as Bergson has so well shown, immediate and local reflexes are gradually complicated as evolution goes on, being extended in space and suspended in time. Living beings progress in so far as they can link their *point of life*, consisting of an instant and a centre, to durations and spaces that are greater. Human beings are human because their objective behaviour is neither immediate nor local. Foresight is a first form of scientific prediction. Before modern science however, it was a matter of foreseeing something *distant* in terms of what was *close at hand*, and precise sensations in terms of crude ones; objective thought developed even so in

contact with the world of the sensations. Now, it does seem that the twentieth century has seen the beginning of scientific thought *against* sensations, and that we need to construct a theory of the objective *against* the object. In the past, reflection resisted the first reflex. Modern scientific thought requires us to resist the first reflection. The very use of the brain is therefore called into question. From now on, the brain is no longer unreservedly the appropriate instrument of scientific thought, in other words the brain is the *obstacle* to scientific thought. It is an obstacle in the sense that it co-ordinates our movements and appetites. We have to think *against* the brain.

This being the case, the psychoanalysis of the scientific mind now takes on its full meaning: like the emotional past, the intellectual past must be known as something that is indeed past and over. The lines of inference leading to scientific ideas must be drawn starting from their real place of origin; the psychic dynamism running through them must be closely watched; all sensory values must be demonetised. Finally, in order for there to be a clear consciousness of phenomenological construction, *the old must be thought in terms of the new*, this being the essential condition for founding mathematical physics as a rationalism. Alongside the slow and hesitant history of what has been, we must then write a rapid, decisive history of what ought to have been. This normalised history is not really inaccurate. It is incorrect socially speaking, in the real rise of popular science which, as we have tried to show in the course of this book, perpetrates each and every error. It is true by virtue of the line of geniuses, in the sweet solicitations of objective truth. It is this delicate line that sketches the real destiny of human thought, gradually rising above and overhanging the line of life. If we follow this delicate line, we see that interest in life is supplanted by interest in the mind. And so as to assess *value* here, we can see *usefulness ascribed to the mind* as clearly apparent, a usefulness that is intellectually very dynamic whereas the *usefulness ascribed to life* is particularly static. What serves life will immobilise it. What serves the mind will set it in motion. The theory of *interest* is therefore essentially different in the realm of biology and in that of the psychology of scientific thought. Linking the two interests – interest in life and interest in the mind – by a vague kind of pragmatism means bringing two opposites together in an arbitrary way. Distinguishing between these two opposites and putting an end to the mind's solidarity with vital interests is therefore what the psychoanalysis of the scientific mind has to do. The animist obstacle is a particular problem here since in almost every century, it insidiously reappears in a more or less up-to-date biological form; only once this obstacle has been reduced can we hope for scientific thought to be really dynamic and enlivening. However, as Édouard Le Roy has so quietly and impressively said, for this general success of scientific thought to be possible, it has to be *willed*. There has to be a strong social will in order to avoid the polygenism that Le Roy does not rule out as a possibility. Indeed, he fears a rupture between liberated souls and souls weighed down by heavy burdens.[10] While the *will of the mind* is very clear in some lofty souls, it is obviously not a *social value*. Charles Andler made this profound remark in an article published in 1928: 'Rome was no more able than Greece had been to make science the basis of education for all'.[11] We ought to take this remark to heart. If we were to look beyond the school syllabus and see the psychological realities, we would understand that the way science is taught needs to be completely reformed; we would realise that modern societies do not appear to have made science an integral part of general culture. By way of excuse, it is said that science is difficult and specialised. Yet the harder something is, the more it teaches us. The more specialist the science, the greater is its demand for mental concentration; the greater too must be the disinterestedness that inspires it. The principle of *continued culture* is moreover at the root of modern scientific culture. The modern scientist is a more apt recipient than anyone else of Kipling's austere advice: 'If you can see your life's work suddenly collapse, and then start work again, if you can suffer, struggle, and die without complaint, you'll be a man, my son'.[12] Only in the work of science can you love what you destroy; only here can you continue the past by repudiating it, and honour your teachers by contradicting them. When that is the case, schooling does indeed go on throughout your whole life. A culture that is stuck in schooldays is the very negation of scientific culture. There is science only if schooling is permanent. It is this schooling – and this school – that science must found. Social interests will then be reversed once and for all: society will be made for school, not school for society.

NOTES

1 Bachelard does not give the source of this quotation.

2 Bachelard quotes in English here.

3 Bachelard's footnote: cf. Édouard Le Roy, *Revue de Métaphysique*, (April, 1935).

4 Bachelard does not give the source of these lines. I am grateful to Professor Malcolm Pender for the following translation:

'Rarely have you understood me
As I rarely understood you.
Only when we were both in filth
Did we understand one another instantly!'

'Kot' means both filth and excrement.

5 Bachelard's footnote: Federigo Enriques, *Signification de l'histoire de la pensée scientifique* (Paris: 1934), 17.

6 Bachelard's footnote: Constantin von Monakow and René Mourgue, *Introduction à l'étude de la neurologie et de la psychopathologie: intégration et désintégration de la fonction* (Paris: Alcan, 1928), 83.

7 Bachelard's footnote: Léon Brunschvicg, *Le Rôle du pythagorisme dans l'évolution des idées* (Paris: Hermann, 1937), 6.

8 The phrase 'bitter wisdom' (*amère sagesse*) echoes a well-known line in Baudelaire's poem 'Le Voyage': 'The bitter knowledge (*amer savoir*) journeys bring'.

9 Bachelard's footnote: see *Revue de Synthèse* (October, 1933), 129.

10 Bachelard's footnote: Édouard Le Roy, *Les Origines humaines et l'évolution de l'intelligence* (Paris), 323.

11 Bachelard's footnote: see *Revue de Métaphysique et de Morale* (April, 1928), 281.

12 Bachelard's rather free version of lines from Kipling's 'If' has been translated here; it would seem to be based on the following lines in the original poem: 'If you can .. watch the things you gave your life to broken ... and start again ... and never breathe a word about your loss ... you'll be a Man my son!'

Index

J

K

L

M

N

O

P

Q

R

S

T

U