Art and Scientific Thought

To
JESSIE

Art and Scientific Thought

Historical Studies towards a Modern Revision of Their Antagonism · BY MARTIN JOHNSON WITH A FOREWORD BY WALTER DE LA MARE

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Foreword by Walter de la Mare

My only excuse for attempting to say a few words concerning this book is an intense interest in its contents. But this alone might certainly not have persuaded me against my better judgment if Dr. Martin Johnson had not wished me to do so, although he was well aware of the inadequacy of his envoy. There is not a shred of modesty in this confession. How could there be?—since the most unusual and arresting feature of the studies that follow is their range, their substance and authority, their insight and sensibility, and their method. Even more unusual is the angle, the standpoint, of their survey—that of a man of science who is also a devotee of music, painting, and poetry. Once upon a time a dainty dish, in the shape of a pie, was set before a king. It contained twenty-four heart-entrancing blackbirds.[1] Hardly less rare must be a book written in the service of so many of the Muses, a treatise vitally and richly concerned with so many of the arts and *their* science; and, above all, with what may be called an aesthetic contemplation of Science itself. In only one direction here can I profess to be more than a dilettante—a term however, which (as with amateur in its relation to love) need not exclude a genuine delight.

Dr. Martin Johnson mentions the many talks we have had together, most of them before any of these chapters had first appeared in print. They ranged in every direction; poetry being my centre, my headquarters, so to speak; the complete ambit of science his. Cardinal Newman once remarked that any fool can ask unanswerable questions; Dr. Samuel Johnson, that a gentleman refrains. What matter? We are as God made us; and friends don't mind. He became my most indulgent 'Enquire Within', undistressed by his friend's lifelong habit not only of indiscriminate interrogation but of insisting on arguing in relation to what that friend knew practically nothing about. How many times, I wonder, did I attempt to compel him to concede that no Universe—of *any* dimensions—can be of much account without a comprehensive consciousness capable of the completest appreciation of it in

[1] And this by no means inappropriately reminds me of another pie which was served up to an actual king—Charles I—by the Duke of Buckingham. The removal of its crust revealed Jeffery Hudson, precisely eighteen inches high. There are statures in intellect.

every detail. *That*, he most patiently reiterated, is not the concern of Science. With these talks in view, he refers to his *Socratic* questioner.

But then!—Socrates was not only heretical but dangerous in the eyes of his enemies on account of a wisdom to which they were blind (as may be certain devotees either of the arts or of the sciences in respect to the main thesis of this book). And no one but a gentleman nonpareil could have been the subject of the *Phaedo*. *His* method indeed was to reveal how hazy was the knowledge and how vague were the sentiments of those whom he catechised, while being himself perfectly assured that he knew the right answers, which he thereupon elucidated. My own feeble and precarious situation was precisely the reverse of this. And especially, needless to say, in respect to the Muse called Urania.

Like any other novice (and this book is by no means intended solely for the expert) I could lapse into a momentary daydream over photographs of the nebulae of Andromeda or of Coma Berenices; could even hazard a mere guess whether its myriads of suns in their assembly suggested the spiral or the concentric; could intelligently enquire whether any such spiral was in process of winding up or of unwinding; and could faintly realise the difficulty occasioned by the varying stellar distances in unimaginable light years for any rapt student considering them on earth. But little further. I had no objection, rather the reverse, to abiding the crucial questions, mathematical, metaphysical, thus involved, as too Dr. Johnson magnanimously abided my own little simplicities, though in a different sense! But here there is less reason even for modesty; much more for shame and reproof. And it is here that we approach one of the paramount intentions of this book.

Nowadays there is little excuse for staying ignorant, though there is immeasurably more excuse than there used to be for woefully failing in any aspiration to become omniscient. There is still less for remaining unconcerned, for being inertly insistent on the practical, the materialistic, the prosaic, or for deliberately confining the mind in minute compartments of that astonishing ship called Human Destiny—compartments which, even if they have the merit of being watertight, can hardly avoid being also rather airless.

To an extraordinary degree, lovers and practitioners of the arts (and, as Dr. Johnson points out, an imaginative and proficient scrutiny and appreciation either of a picture, of a song, a symphony, or a poem entails an art that is also in itself creative)—it is astonishing how many of those who ardently delight in these things

may yet be comparative strangers to the aims, methods, ideals and to the art of Science. Contrariwise, and with less excuse perhaps, how few minds and intellects devoted to science seem to pay even so much as lip service to the arts. The happy marriage in a true mind between knowledge and that poetic experience which is the wellspring of all the arts was once unquestioned—by Leonardo no less than by the ancient Chinese. Nowadays between Science and this poetic experience there is danger of a definite divorce. An increasing cleavage between them is rapidly becoming an abyss. To attempt to bridge this gulf is one of the purposes of this book. The fact that there is this cleavage is unquestionable. A writer in the current issue of the *Queen's Quarterly*, for example, insists on it as crucial in his Canadian university. That Lord Wavell, on the other hand, a master in the art and science of war, *during* the late War, should have published an anthology consisting of poems he has committed to memory may be greeted by many as a strange if not unseemly paradox. No less so that Russia refuses to permit the most precious of her artists to risk their lives in battle—not for love of their *beaux yeux*, not assuredly with these artists' approval, but because they are especially precious to her, and may prove of sovereign value in her future. In this resembling her men of science.

None the less in what degree poets and other artists have been, should be, and are students of science; and to what extent intimacy with pure science would aid their inspiration, are fascinating problems. Robert Bridges, I have read somewhere, became a doctor of medicine in the belief that the practice of this profession is the best discipleship to poetry. William Butler Yeats said of Mr. Walter Turner: 'I think of him as the first poet to read a mathematical equation, a musical score, a book of verse with equal understanding. He seems to ride in an observation balloon, blue heaven above, earth beneath, an abstract pattern,' a statement very exceptional regarding poets but certainly no less true of the author of this book both as a man of science and as a student of the arts.

Rossetti's reference to the necessity of fundamental brainwork in the writing of poetry is now a valuable byword. That brainwork indeed is the exercise of the *science* of this particular art. Is it of a different order when it is exercised in relation to the study and methods of science? Most poets have to some extent at least shared the curiosity of Sir Thomas Browne, himself a poet in the medium of prose, even though in much they may prefer to remain the victims of Vulgar Error. Sir Thomas Browne's scientific opinions,

it is true, were 'often of small value'. He held 'that the earth was stationary and could not possibly move; he believed in witchcraft; and he was persuaded that it was possible to restore a flower to its first beauty after it had been burnt to ashes.'

Mere superstitions or not, here are involved two kinds of truth, namely, the validity of fact and an innate conviction of the truth of the imagination, of that insight which is an irresistible but by no means impeccable mentor. Instinctive preferences of course may be of little value—the carking *wish*, for example, that this world *were* stationary and not a vertiginous ball infested with inhumanities and hurtling through space. Of no more substance and efficacy may be the haunting conviction that the phenomena intrinsic in witchcraft, whether in relation to the human mind or to the powers of darkness, are not dismissible with a shrug of the shoulders, but rather with a shudder of the heart; or the enchanting aspiration that a time, or that a no-time may actually arrive when (every flower being itself a repetitive miracle) it may be possible to restore a specimen—daisy or lotus—to its first beauty after it has been burnt to ashes. Even a child may be cremated.

Does this ingenuousness merely imply that a certain type of mind prefers within certain limits to remain mystified—which is not quite the same thing as remaining mistified? That poor thing, yet one's own—one's imagination—may it legitimately keep open house to the wonders of life and of the world and yet remain guilelessly devoid of any desire to circumscribe them within the cage of fact? 'As a man is,' said Blake, 'so he sees. As the eye is formed, such are its powers. You certainly mistake, when you say that the visions of fancy are not to be found in the world. To me, this world is all one continued vision.' Wordsworth, again, with whose ideals William Blake was by no means in harmony, declared that 'poetry is the breath and finer spirit of all knowledge; it is the impassioned expression which is in the countenance of all science'. The disciples of Urania long ago discarded that eye as the unaided means of contemplating the remoter heavens. How far then is it not merely natural but safe for the man of imagination to preclude himself from their abstruser discoveries? The inconceivably remote and the exquisitely minute are much the same thing in effect to the contemplative mind. And it is not the number of light years severing the observer from some scarcely imaginable nebula that so much concerns the imagination as the active power to be pacified by the serene beauty of the Evening Star, or elated by the global brilliance of a drop of dew. Mere knowledge of

course is no more necessarily a means to wisdom than the taxidermist's stuffing is to the revivification of some lovely song bird. An indigestible repletion of knowledge will constrict or stupefy, may even stultify the mind, and stifle impulse.

The word Science—like so many other words in heedless use—is as wide in amplitude as it is vague in reference. As signifying a method, it is exact. In respect to its matter it is universal. Crowned with a capital letter it is both nebulous and arbitrary. It is rapidly becoming the monarch of all it surveys, and now dominates subjects or serfs largely ignorant of its powers, its virtues, or even its aims. It threatens to become a dangerous autocracy, and to its professors a shibboleth. Here, in respect to its real understanders, the answer to a nonsense riddle for once comes true—'the higher it goes the fewer'.

None the less, any science is within the range of every man who has the requisite intelligence, the means of ascertainment, the assiduity, and above all the time. He should be ashamed to have neglected its most generous hospitality; since what he can thus attain may be of sovereign value, and, in the attaining of it, also a matchless discipline. Talent can achieve of it as much as, but no less than, the mere opportunities of but one lifetime will permit. Poetry, any art, on the other hand, is essentially different. Mere endeavour will neither achieve its creation nor win the secret of its power and beauty. It does not age; it is never superseded; it is a universal language, acquirable in its fullness only by a genius commensurate with it. No true poem is the outcome of a purely ratiocinative process. That process is not only rational, it is also preter-rational. So too with mysticism. So too with every individual religious sense and conviction. 'Differences', as Dr. Martin Johnson declares, are apt to arise only 'as soon as we attempt to name, and define, the "object of our worship".' As with poetry, the experience relating to these is unique in every case; and *per se* is therefore beyond and outside of the investigations of Science, which is solely concerned with the ascertainable that may be subjected to limitless check and ratification.

Nevertheless Science instructs, and at its best combines that instruction with the giving of delight. This is emphatically true also of poetry; except that the delight, the impassioned joy it may surrender, may be declared to be of greater value than its instruction, although by its means both are within the reach only of those who are innately familiar with its half-secret language. There is no half-secret language in Science. Indeed, the artist in his work may shun

and refuse to teach openly, to point his moral (as may also the man of Science), not necessarily because an obvious lesson would ruin his work. That might quite easily be disproved. But because it might destroy and defeat the wisdom and ethic inherent in his work. And this is of its very essence. A 'Song of Innocence', a still life by Chardin, an aria of Mozart's, a worked fragment of Chinese jade are interfused through and through with a meaning of a simple yet profound order which is wholly incommunicable in other terms. Nor is it the text of man's mortality that is the mainspring of Holbein's woodcuts in the 'Dance of Death'. Their sovereign efficacy is the conviction in every line that in the intensity of his realisation of his theme he has himself called the tune. The statement that God is love, or that the Word was made flesh is mere knowledge until it is transmuted into wisdom. Neither statement is even true in any intrinsic degree until each is given the truth that is *in us*. 'The domain of faith and the domain of proof are . . .' both essential but different constituents of our mental outlook. Any *proof*, again, of the beauty, and even of the significance, of a fine poem is unattainable. These also at least trespass into the domain of faith. Nevertheless—and not loosely speaking—both artist and man of science (as this book reveals so much more fully, profoundly and variously than I can hope to suggest) may be said to 'create' the form of what they believe in. Their 'secret sharers' must have faith in what they themselves create out of the created, through insight and divination. Proof derived from experience, knowledge, analysis, comparison, may follow this. It cannot precede it. Ours is 'the heritage of the child calling out in fear of the dark, the divine answer is for each of us alone'.

The poet, whether in his innocence or ignorance, will rapturously emulate the engaging cow of the old nursery rhyme that jumped over the moon when he reads that in the physicist's view matter has taken 'upon itself some of the aspects of empty space, fantastic nightmare though this may be, for the materialists, if any still survive'. For equally private if not satisfactory reasons he may joy to read that 'the finality of the views current in the nineteenth century is a lost vision; and we can only be grateful for release from the nightmare of a knowledge so complete as to be uninteresting'. Not by any means that Dr. Martin Johnson would himself approve of even a novice's emotionalism. That indeed is the veritable bugbear of all men of science. But if, as Mr. George Hamilton maintains, the making of a poem is the outcome of an act of contemplation, so too, I assume, *in excelsis*, with the outcome

of the pursuit of pure science. And even the groping tyro should be able, however faintly, to realise that a sort of blissful and celestial Nirvana—if this is not a contradiction in terms—may be the sovereign if inexplicable recompense of both.

Reason has moons, but moons not hers,
  Lie mirrored on her sea,
Confounding her astronomers,
  But, O! delighting me.

Author's Preface

These groups of short studies, and the discussions which link them, are put forward in a belief that likenesses and not only contrasts exist between the two traditionally antagonistic attitudes, the logical or scientific on the one hand and the imaginative or poetic and artistic on the other. It is conceivable that comparison between the two might benefit both; for the tradition of isolation and antagonism is a recent consequence of modern centuries of specialisation, and it now shows signs of giving way to a spasmodic intercourse between the sciences and the arts which is sometimes enthusiastic but usually bewildered. Such intercourse is apt at present to be the contact between strangers speaking different languages; science at least is vastly more complex than when Leonardo da Vinci and the mediæval orientals practised arts and philosophies indiscriminately, so that the current epoch calls for definitions and mutual recognitions to replace those which through centuries of disuse have fallen out of phase, if not out of date. It will be of some interest to see where there has been any alteration in the fundamental approach of the scientist to nature.

There is even a reason for raising such discussion during a war whose minor consequences include a severe shortage of paper and printers, and whose other consequences have certainly diverted the energies of author and most readers into channels more immediately urgent than the academic; for it is particularly among the scientific trainees for war-time technology that questions are most urgently being asked. They insist upon enquiring what contribution a scientific outlook will make towards those human orientations which are also influenced by poetry, music, and the arts.

In larger issue a similar problem overhangs already the educational plans for Reconstruction: science is officially patronised during war-time as the source from which convenient or necessary inventions may be expected, but will it remain in peace-time a mere minister to material ease and facilitated communications? Or can it become a clue to our insight into the meaning of human nature's environment, and achieve an influence upon education in the widest sense comparable with that of studies which used to monopolise the title 'humane'? In the future such questions will

have a vital urgency, when a peace is to be won in addition to a war. So there need be no hesitation in responding to the hints given by various of the younger students of science, among whom enthusiasm for the arts has lately been showing at the very least as striking a vitality as among the professed followers of more obviously literary studies.

Several of these essays are reprinted, with some revision where desirable with respect to the different public and form of publication, from older papers by the author in journals of science and art. The Jade, the Sculpture, the Beethoven, have thus appeared in *Apollo*, to whose editor thanks are due. A brief and compressed summary of the Leonardo conclusions appeared in *The Burlington Magazine of Fine Arts*. A slightly more technical version of the Bagdad Mathematicians appeared in *The Observatory*. The essay on the Chinese Instruments was in proof form for *Isis* when the Germans invaded its printing works in May 1940, and the editor welcomes publication elsewhere since the lost issues can only be resuscitated—as he says—'in Belgium, God knows when'.[1]

Some few of the essays, in particular the Leonardo group and the Peking Instruments, were specialist investigations originally undertaken for their own sake, before the war, and are adapted here because of the light which they cast on essential features of the relatedness between scientific and imaginative mentality, which is the main thesis: none of the essays is specialist in the sense of requiring previous acquaintance with any branch of science, history, or art. Any of them can be read separately, or the several introductions and conclusion can be read together before turning to the separate studies which illustrate the argument in detail.

Specific acknowledgments have been, and will be, made at the appropriate points in the book. There are one or two more general debts: first of all to Mr. Walter de la Mare. For years he has permitted me, indeed generously encouraged me, to argue frequently with him the philosophy of science and of art. Without his Socratic persistence in propounding novel and disconcerting questions, and in teaching me to query all assumptions underlying his own trade and mine, this book would not exist. He must not, of course, be saddled with the opinions therein: but I am hoping most of all that I have not touched with too clumsy a hand his own most exquisite poetry and thought.

For generosity in regard to photographic material I am indebted

[1] Since the first edition, 1944, the essay lost in the European War has been resurrected by the editor of *Isis* and published in that journal.

to the Royal Library at Windsor, to Sir Kenneth Clark, to Messrs. Jonathan Cape, to the Victoria and Albert Museum, to the late Dr. Mingana, and to certain French publishers now placed by war beyond reach of my requests or my thanks. Professor Thomas Bodkin and the Barber Institute of Fine Arts have given unfailing kindness and help to a scientist intruding in their domain.

There is also a debt to many students, mainly of science or of medicine, in Birmingham University, who have repaid my attempts to interest them in the study of Physics by talking to me about their enthusiasms in art, music, or poetry. Finally, a technical assistant in this laboratory, Miss Constance Reading, has given valuable secretarial help during the editing of much that was in the form of pre-war essays and notebooks.

Contents

PART THREE

Historical Failure to maintain a Balance between the Scientific and the Imaginative

PART FOUR

Leonardo da Vinci as Scientist in Art: his fantastic Drawings and the Prototype of Scientific Uneasiness in an Unscientific Community

Introduction

What conceivable connection can cast into a single volume essays concerned with sculpture, music, poetry, and on the other hand even the briefest reference to the modern electrical theory of matter and the time-space framework of scientific measurement? Incongruity might seem still worsened by adding a few studies on ancient Chinese instruments and on the migrations of early mathematical knowledge through the medieval East, not to speak of attempts towards novel insight into Leonardo da Vinci and Spinoza—those enigmatic giants who bestride the gaps between science, art, and philosophy in the comparative simplicity of pre-modern knowledge.

But the selection is not the rambling hobby of a scientist relieving the intensity of experimental work by occasional trespass into lesser-known byways of art and archaeology. Stimulated by a fact of experience, namely that the author's students and colleagues in Faculties of Science and Medicine have taught him more about the arts than much official art-criticism, these studies are collected in the hope of seeing just how there arise the contrasts and subtle similarities which make so many scientists turn for recreation to the arts—and which might well make suitably expounded science a valuable item in the educational programme for the arts. Such recreation is much more than idle pastime, and becomes at times of hard work an intellectual and spiritual necessity. In any reconstructed system of education the poet and the artist will have to explain to the scientist, and the scientist to the artist, what each is trying to do: this will require something more penetrating than the mere popularisation of salient facts of scientific discovery, for which there are booksful of exposition already in plenty. It will require a mutual realisation of likenesses and differences between the logical and the imaginative in our response to human environment. A tentative approach to such problems is offered in the present thesis that the sciences and even the most fantastic arts are essentially essays in Communication of Pattern, Form, or Structure of mental images. The scrutiny of this common feature may well be of greater significance than any hasty decision as to whether the scientist's work is to UNCOVER pre-existing pattern in nature, or, like the artist, to CREATE his patterns. Such decision belongs to

metaphysics and not to the logic of science or to art criticism, and in these essays it is not attempted. Trespass over the boundary of this colossal ambiguity has occasioned the wreck of most modern accounts of science written for the non-scientific. In fact, if any academic label of study were unfortunately to be attached to the present enquiries, I would claim to be discussing not the philosophy of science and art so much as their psychology. I ask, for instance, how the artist and scientist have faced their respective obligations, where in history have there been misfits between their ambitions and fulfilment, and under what future conditions they may regard one anothers' labours with some degree of mutual respect.

Such a sequence of questions determines the somewhat unorthodox structure of this book. In Part I is developed the view that the artist, sensitive to impressions from nature and human nature, only acquires his significance for society by communicating his vision through a Pattern or Formal Structure which his technique can impose upon some selected medium. Whether musical sound, material shape, manipulated colour, or verbal imagery, the character of the medium itself matters little and the resemblance of his work of art to any scene or sound or object matters little, compared with this essential function of becoming a channel of communication. Someone's imagination must become aroused to the individual re-creating of the artist's vision. In caring so little for any likeness between a work of art and either nature or history, we recollect that the entities of greatest interest in modern physics may also be far removed from recognition in direct sense-experience, though for different reasons. But unsuspected compatibility of aim between artistic and scientific endeavour also arises from the fact that modern physics is an attempt to bring order into the chaotic structures of individual knowledge. 'Relativity' means recognition that laws of nature must be restated in universally communicable form and that science must be emancipated from the biasing significance of any particular observer. In this may be seen both the likeness and the contrast between science and imaginative art: each communicates by employing a technique of ideas not completely describable in terms of sense-experience, but the one labours to make its communications capable of identification or correlation by all possible individuals, while the other insists that each individual must translate the original vision into something peculiarly of his own creation.

Applications within the physical sciences are scarcely controversial, and little is required here beyond pointers which may be

followed into an enormous literature, popular or technical. But in art there has been less agreement among practitioners, critics, and theorists. It is perhaps in the extremes of imaginative, even fantastic, art that the principles become self-evident, and Part II as a sequel to Part I is intended to discuss instances selected from widely separated epochs. These instances are particularly drawn from byways seldom explored, and have been chosen for their emphasis on the arousing of imaginative response: in all of them this feature will be found of vastly greater importance than any direct copying of nature practised in the more representational arts.

A natural sequel would concentrate the remainder of the book into pleas for the official encouragement—hitherto lacking—of scientific studies among students of arts and artistic enthusiasms among students of science. But that would imply a too facile optimism and a shirking of the most difficult intellectual problem of the age. Both by historical accident and by the misfit of incompatible temperament, the contacts between science and art have brought one or the other to contempt or frustration. The resulting danger to any plans for future combined education is not easy to see or avoid in the welter of current scientific progress and artistic fashion. It is a main purpose in Parts III and IV to investigate such danger of misfit, and to realise the circumstances of it in the history of early communities which encouraged science with art and philosophy, and also in the history of one individual who was supremely scientist and artist.

In Part III the uneasy partnership is examined in some historical phases seldom studied. In recent centuries the combination of artist and scientist in one personality has been mere occasional freak, and we have to go back to an incredibly simpler science and a less sophisticated art if the logical and the imaginative are to be seen clearly as in embryo. Classical times have been overstudied, with bias from non-scientific and non-artistic preconceptions, and it is arguable that the simplest and most enlightening periods of history for my purpose are ancient Chinese—only nowadays dawning on the West as important to civilisation—together with the remarkable renaissance of the medieval Moslem world. This latter, during the twilight and dawn of European thought, prepared the knowledge without which modern science would certainly have been delayed and perhaps crippled at birth. If these essays do a little towards undermining the popular academic fallacy that Bagdad and Persia merely sat quiescent upon the debris of classical art and science, a useful secondary purpose will be fulfilled.

But the same studies also reveal the inhibiting paralysis which sets in when aesthetic convention is allowed to control scientific decision. At the present day the onset of this paralysis is more subtle and is occasionally complicated by a toxic effect of pseudo-scientific convention upon art.

In the case of Leonardo da Vinci there occurred no such poisoning of one discipline by the other: he is the simplest and therefore most illuminating historical example of the scientific attitude carried to an extreme and then exposed in a draughtsman's technique. He has long been known to be the classic instance of combined artist and scientist, but my interpretation of the combination is not along conventional lines: I find that there was a bondage to social environment, upon him and upon those who might have learnt from him, which stands as a warning for ever. The aspect of his art with which I deal, the drawings and illustrations to MSS., express more fully perhaps than any known historical document the implication of disillusion forced upon a scientific philosopher in an unscientific civilisation. The effect upon his art is a novel topic for investigation, for which I develop a tentative beginning. (Part IV.)

It is an even more unconventional novelty to regard the philosopher Spinoza as involved in any problem of aesthetic. But I have set him beside the other tragedies of misfitting the scientific to the imaginative, because I wish to suggest that, in common with the Orientals, his choice of medium for expression was an artistic one where it ought to have been a purely rational decision.

These discussions cannot be completely dissociated from the troubled relations between science and religion, and in a final essay of Part III I suggest some bridges over traditional chasms, by way of scientific approach to a religious experience which is strictly comparable with that of the artist.

There have been failures and tragedies enough, in the arts, sciences, philosophies, and religions, through misreading of the extent and limitation of their common principles; but the conclusion from the entire set of essays implies not only warning from the past but hope for the future. Even the disappointing history of philosophers in the twentieth century, trying to absorb the results of physical science while physicists try to philosophise, might have been less disastrous if the mentality of ancient and medieval and early modern practitioners of arts and sciences had been carefully regarded.

PART ONE

Features of Resemblance and of Contrast between the Arts and the Sciences

Chapter 1

Introduction

Fact and fancy, exercise of the reason and of the imagination, training towards the logical and towards the visionary, surely these are pairs implying not merely antithesis but antagonism? It is important to decide whether the hostility so often suggested by these contrasts is inevitable, or whether it is a superficiality; suspicions grow with lack of acquaintance when educational economics confines the individual to scientific or to literary training, and any trespassing across the border between the two becomes a serious offence. It is conceivable that the scientist with artistic enthusiasms and the artist reading or enquiring in science are merely indulging in the piquancy of unfamiliar flavours. But it is also conceivable that the scientist and the artist, each at his own work, are in some real sense pursuing the same aim and by methods having more in common than is usually admitted.

The possibility that there is territory common to both might develop from two observations; firstly, the distinction between scientific knowledge and random opinion is that the former requires a pattern or logical structure rendering it universally communicable, so that it becomes subject to acceptance or rejection by all who abide by an agreed canon of argument. It will be shown that recognition of this in quantitative discussion is the basis of the physics of Relativity. Now criticism and appreciation in the arts will be found also to depend upon a notion of 'communicability', but with certain differences of interpretation. The second possibility of common aims and methods arises from the insistence by modern physics upon 'objects' such as electrons and atomic nuclei, which have no direct resemblance to the objects of perception by our senses: for at the same time the whole tendency of modernism in the arts has been towards freeing the artist from the primitive

duty of producing a photographic copy of natural objects accessible to sense perception.

These two directions of possible resemblance are discussed together in Part I, and give rise to criteria for the judgment of important but disputed tendencies in art, and also for the understanding of recent trends in physical science. It becomes profitable to regard art and science as each attempting to communicate mental images through patterns and structures and forms, in the qualitative domain of feeling and in the quantitative domain of measurement respectively.

That a work of art should have a form of its own, not tied to being a copy of what we see or touch in nature, suggests that a first approach to the character of imaginative or fantastic art might start from this tendency to redraw the world independently of any direct evidence of the senses. Such a practice might well be ascribed also to the modern physical sciences. For characteristically in physics we habitually assert that our sense-experiences of bulk matter, such as finding that it has colour and smell and carries sound and heat, and is impenetrable, all cover a real world of electromagnetic forces acting in the almost vacuous spacing of atomic structure. Matter in many of its most 'material' aspects is a mere consequence of the way in which an animal's nervous mechanism is constrained by its electrochemistry to function. The criterion distinguishing scientific knowledge from guesswork or quackery is therefore not any accessibility of its 'objects' to direct sense-perception. Actually a scientific theory is a mental construct, subject primarily to indirect justification: it becomes acceptable if tested to the utmost rigour by its capacity to predict mathematically some new experimental result, which anyone anywhere equipped with the appropriate laboratory apparatus and mathematical language must be able to verify or to refute by repetitions all yielding the same answer. Thus the test of validity of the scientist's 'pattern' of ideas is that its form must render it communicable. This is a more penetrating as well as a more practical test than any which ask whether scientific entities are 'discovered' or are 'created', or are 'imaginary' or are 'real'—alternatives relevant to metaphysics but irrelevant to science and also to art.

Has this test of communicability any counterpart for the imaginative arts? I suggest that it has, and that legitimate fantasy in art is distinguishable from mere caprice according to whether it has a definite pattern or form capable of communicating a coherent state of mind from artist to public: a test comparable with the

sifting of genuine science from quackery. I propose to develop this thesis by approach from the direction of the arts and then of the sciences, with detailed example in the studies of Part II, before turning attention in Parts III and IV to the way in which historical facts reveal failure in various civilisations to apply the appropriate criteria and limitations effectively.

Chapter 2

Scientific Criteria in the Communication of Feeling by Imaginative Art

I

Whether we owe our deepest appreciation of the arts to their unrivalled consolation in hard times, or to the insight into human nature which we demand from the artist in good and bad times alike, the attitude in which we approach any picture or music or poetry can be decisive in permitting or preventing the full realisation of its powers. The approach commonly fails through uncertainty as to the effort demanded from our individual imaginations; this uncertainty afflicts especially those who possess a ready enjoyment of some one form of art, perhaps musical or literary or decorative, but who almost pride themselves on their inexperience of other arts. In the end they are tragically inhibited by the attempt to make familiar decisions of their musical or poetic or pictorial judgment apply in the unfamiliarity of a new domain. The interplay of imagination and common sense in this judgment becomes capricious and wasteful in the dramatic enthusiast's anxiety for 'story' in music or ballet, in the pathetic search for 'meaning' which often interrupts delight in the verbal impressionism of poetry or fine prose, in the recurring antagonisms between symbolism and realism—and now surrealism—of painter or sculptor, and in many futile disputes of 'function' for decorative arts and crafts. It is further unfortunate that any contact between more imaginative and less imaginative phases of art is prejudiced by attachment to the various theories of aesthetic developed with extraneous, often metaphysical, aims; so I shall attempt here to be independent of much philosophical preconception by using such distinctions only in the very broadest sense which might be acceptable in all possible theories.

In attempting to resolve any ambiguities associated with the imagination in art, it will be well to deal mainly in examples from the more abstract, even fantastic, arts: for it is with regard to these that a critic's respect for obvious fact leads him to suspect all use of the imagination as implying descent into a world of delusion.

Other kinds may indeed escape the need for much enquiry, since they depend less upon artist's or beholder's imagination and more upon the precise representation of familiar objects from our material environment: even the narrowest definition of fact permits the critic to approve the direct copying of nature by skilled craftsmanship. But when the picture or sculpture or poem has no longer any obvious link with sense experience, a creative imagination is required of the beholder or reader in interpreting a work in which similar imagination has been employed by the artist. It is in such cases that enquiry becomes necessary as to whether the communication between the two imaginations has significance for human intelligence and well-being, or whether on the other hand it is shirking the duties of realism.

When a picture or a sculpture or a poem has been constructed with free use of the imagination it will probably be stigmatised as fantasy: the critic's attitude in using this term may be either contemptuous or enthusiastic, but his intention will go astray unless he has cleared his mind with regard to the traditional antagonisms between the fantastic and the real. At the present time of unprecedented human suffering, it becomes especially urgent to re-examine such traditions: for in the dark of experience men call for the exquisite consolation of the imaginative arts, and yet shrink in pride and honesty from any mere narcotic. Is imaginative or fantastic art only a base attempt to escape from the painful world by creation of an unreal refuge, enabling cowards to shirk for awhile the things they dread by wandering in a maze of images sufficiently intriguing to obliterate reality? Or does the metaphorical moonshine of such imagination illuminate real mental depths and heights, so that the adventitious and the momentary cease to monopolise our attention? Can it even permit the more permanent to emerge, if only from a subconscious not entirely disreputable, until we learn to see things *sub specie aeternitatis*? According to our several philosophical prejudices, such vision of eternal truth might be regarded either as glimpse into our own internal potentialities, or as insight into the nature of the external world: on either alternative there is available an illumination which it is a main task of life—and of science—to attain.

II

The answer to these questions and uncertainties, and the resolving of these ambiguities, can only lie in the discovery of

criteria for testing the legitimacy of imaginative art. What can justify its title to be at least as realist as the more frankly descriptive or the almost photographic copying of nature? This requires first a more precise delimitation of non-representational elements in art, and of the creative share of the artist's public in the success of his communication. Examples from well-known phases of art history might then illustrate principles for guarding against the descent of fantasy into mere caprice and escapism.

It is not difficult to recognise at once a separation, already hinted, between representational and non-representational types of art: the latter I prefer to call imaginative and are commonly called fantastic. Suppose that any artist is adequately sensitive in his perception of the contrasts between pathos and delight in ordinary life and in its more catastrophic occasions; then there are broadly two ways along which his vision may be communicated, to reappear as insight glimpsed by those who appreciate his works. It is the necessity of this communication between artist and public which imposes the broad distinction between representational and imaginative, although these vague and unsatisfying terms permit the distinction to fluctuate disconcertingly. In representational arts, an object or a situation is depicted or described, and makes up the 'content' of a picture or a shape or a poem, and the work as a piece of communication can be judged according to the plausibility with which this content is made recognisable; for instance an etching of a tree or a painting of a sunset is expected to 'look like' tree or sunset. On the other hand, non-representational or symbolic or abstract arts, which depend upon fantasy of the imagination, require more collaboration from the observer or hearer or reader because the 'apparent content' no longer measures the ultimate significance of a work. Here the artist's attitude of mind is not adequately communicated to us until in our own responding imagination there arises a new creation which may bear profound significance but need not resemble any apparent content. Indeed where pattern and form supersede apparent content the latter may be trivial or nonsensical, the frailest of vehicles for the beauty or terror conveyed by the pattern in which it is arranged. For response is aroused more by the manner than the matter in this kind of art.

The latent significance carried to the appreciative mind may vary from one individual to another, even in response to a single work of art: for the imagination exercised by the public is itself a mental activity altering with temperament and mood. The final

image on any occasion will therefore not be unique, and may not be easy to reproduce or describe. But it may well generate an attitude of mind whose shadowy elusiveness in no way prevents it from being a main source of behaviour and of happiness, conferring upon the relevant work of art every title of realism. These varying results in such 'creative' appreciation of a work of art will, of course, reach their strongest by utilising knowledge of the history and environment of the artist and his period; but even the most unlearned, if cherishing the germ of sensitivity with which we are all endowed, can labour towards creating in himself a new mental imagery under stimulus of an artist's work and of the appreciations thereof by previous individuals. Hence a consequence of each man's confession of personal insight—true function of the critic—is that the whole company gathered through many generations around a single great work may differ widely in the images they each create, no one impression being slavishly accepted as unique or authoritative.

I have demanded individual acts of creative imagination on the part of the beholder of a picture or a sculpture or the reader of a poem; it will be urged against any such view that it licences everyone to read an interpretation INTO, and not merely IN, the work of an artist who has said his say and ought to be protected from such interference with his intentions. The accusation may be both true and not entirely damning. Above the welter of historical theories as to the meaning of aesthetic appreciation, I deliberately insist that beholder, reader, or hearer, has a creative duty second only to that of the artist. Unless the beholder's imagination is employed at its fullest sensitivity to play that creative part, the labour of the artist himself is sterilised, and only one side has been constructed towards that bridge by which a state of mind is to be shared between painter, poet, or musician, and his public.

In this view, the essence of art is not mere self-expression, but a genuine communion between even a long-dead craftsman and his kindred spirits in any subsequent epoch. This communion, or act of co-operation embodied in all sensitive response to a painting or carving or poem or symphony, calls for loving care of others beyond the original artist: without necessarily describing ourselves as pantheists, we can discover here the fellowship of one original worker with a whole family of spiritual descendants down the ages. Their appreciation exercises a joint trusteeship over an enlightenment which began perhaps centuries ago and must not be allowed to lapse.

III

The transmission of ideas by means of formal pattern is strongly reminiscent of a process which is the essence of modern science. Indeed communication by pattern or structure in imaginative art has likenesses and differences which may now be noticed, relative to communication by the mathematical form of a scientific theory. It differs by the great variety of the private mental images stimulated by a single work of art, compared with the identity of all identically planned experiments whereby different observers verify a single scientific theory. But however many the fantastic images stimulated by the picture or poem, they may all be as remote from direct sense-experience as is the physicist's atom or electron. They may have equal claim to 'reality' through their practical significance for human destiny and understanding; they must each submit to test of their legitimacy through their usefulness in communicating some coherent state of mind.

IV

This unorthodox comparison between scientific and purely aesthetic communication is able to provide a first clue towards criteria distinguishing good fantasy in art from bad. Science as a crowning intellectual achievement is essentially disciplined; but it is not always easy to realise the need for an equally severe discipline in the domain of the imaginative arts. Imagination and intellect, however, are not always in antithesis to one another. Reason implies not only a capacity for logical sequence of argument, but also a sensitivity to balance and contrast—a trained intuition without untrained intuition's arrogant claims to short-circuit the discipline of the intellect. When the imagination thus becomes disciplined, and undertakes the severest obligations inherent in perfecting the pattern of an art-form, it has taken the essential step towards security against the weaknesses of fantasy. Structure as disciplined as that of a mathematical argument is capable of transfiguring the merest nonsense into divine nonsense.

Actually the imaginative life of the visionary is no idle relaxation, and if he can attain a purification of technique sufficient to communicate coherence through his fantastic carving or drawing or verse-making, he will also have redeemed his soul from the cowardice of escapism. One recalls as symbolic of such discipline

the many years of struggle attributed in legend to the carver of one simple ornament of Jade in ancient China. Without this struggle with the intractable medium of expression, fantasy becomes chaos, as pitiful as the faking of the mathematical proof in a scientific theory; whereas even nonsense-art delicately wrought may claim an imaginative significance so far above any apparent content that complete absence of 'meaning' from its glorious trivialities need be no loss.

The second test to be met by imaginative art arises naturally from the second danger to which it is subject. If the risk of descending to mere caprice is only escaped by sheer craftsmanship's honesty of patterning, the other risk of shirking the responsibilities of realism is only escaped by the artist's possession of an acutely sympathetic humanity. Since I have insisted that the artist in fantasy must demand creative action in the imaginative response of his public, he fails grossly if he lives out of touch and out of sympathy with the human situation of that public. This is a failing which would again reduce his work to a mere narcotic, the selfishness of a retreat from reality by way of dream. It will be found that this essential quality of humanity in the artist is not necessarily a function of any apparent content of a picture or poem, but must be judged solely by the effect it produces: many fantasies in the inanimate, for instance Chinese and some European landscape painting, are vehicles of the profoundest human feeling.

V

These abstract principles of imaginative art must be scrutinised according to any light which they may cast upon familiar experience in various phases of art.

Instrumental music shows the most obvious dependence upon that quality of pattern which we have attributed to the non-representational arts as their means of stimulating imaginative response. The total absence of 'apparent content' in abstract compositions for chamber instruments or orchestra leaves such work free from the perplexities of distinguishing superficial from symbolic significance. Very few would nowadays claim that 'programme music', or the imitation of verbal or pictorial descriptiveness, is anything but a mongrel of doubtful heredity. When we discover Mozart to be the most intimately lovable of musicians, one reason is perhaps that even in his vocal and dramatic work the pattern of melody and harmony and counter-

point is the real channel of communication, rather than any image tied to the words or the apparent content. Most dramatic music, on the contrary, and many stage arts except Ballet which alone is emancipated from the tyranny of the spoken word, tend to rely on the representational or the imitation of life, and not to make full use of fantasy.

The music of Bach is also instructive in its almost total dependence upon pattern, whether accompanied or not by any apparent content of words. When once we outgrow the primitive delusion that a fugue is MERE formalism, we find in Bach a profundity of feeling offering imaginative stimulation unsurpassed in any phase of art. When he does attach a verbal content, the effect is still carried by the pattern: when in the B Minor Mass we are overwhelmed by conviction that the composer of 'Sanctus' and 'Dona nobis pacem' knew with terrible intimacy the implication of the words, the intention and the achievement would be almost as clear if we omitted those few verbal phrases whose repetition makes up the vocal score. It is even possible to outgrow the apparent content of a work of art: the gross programme-building of Strauss and Wagner is better forgotten, leaving us free to delight in the pattern of orchestral colour of which they were such unsurpassed masters. In the greatest of all string quartets, in A minor opus 132, the ethereal canzona gains in ecstasy and strength if we omit Beethoven's verbal labels concerning sickness and health. Perhaps the most perfect examples of unfettered stimulation of imagination by formal pattern are to be found in the instrumental music of Mozart and of Brahms: in the Finale of that structural masterpiece the Symphony in C Major (K551), Mozart brings to one single mood both of the two most formal patterns of musical technique, the fugue and the sonata form, with effects far more emotionally powerful than if their appeal were either verbal or were merely an ingenuity of intricate weaving. In the more sophisticated of centuries, the subtle excursions into change of rhythm and key enable the 'codas' in works by Brahms to confer an unearthly transfiguration upon the very complex structures preceding them: the sacrificial nobility with which he ends the battling Finale to the Third Symphony in F, the tender apotheosis which ends the first movement of the Second Symphony in D, the mysterious and elf-like end to the Scherzo of the Third String Quartet in B flat, are as compelling as movements in the final quartets of Beethoven.

In painting, it is possible that the first experiments by Leonardo da Vinci on the effects of illumination mark an emergence from

the merely representational stage, although the impulse towards fantasy can be traced back to the Byzantine and beyond to classical vase-painting, and had been temporarily lost. The outlying shadows in a portrait by Rembrandt may subtly suggest far more than its shape, and although Vermeer's subjects seem confined to an apparent content of domestic commonplace, he galvanises our imagination by the effect of light itself shining upon an object rather than by the object. Fantasy more openly and less subtly begins to dominate painting with the Baroque of the late Venetians and the Spaniards, who exploited the tremendous effect upon the observer of allowing any apparent content to peer suggestively out of a dimness which obliterates most features of the superficially 'real'; and yet no-one would deny to their most fantastic symbolisms the property of the starkest realism. But only in recent years have some critics recognised that direct representation is not the main function of the painter; it was the French Impressionists and not the English Pre-Raphaelites who stimulated Clive Bell and Roger Fry to a first theorising about the significance of Form.

It is to decoration and the plastic arts that fantasy contributes the most. The future text-book of all imaginative art may well be based upon certain symbolic sculptures which range from the bird-headed gods of ancient Egypt to the soporific carving of Epstein's 'Night', and it must include at its climax the grim distorted stone watchers on Chartres Cathedral which join Byzantine fantasy to the Gothic. About this subject I have written in detail in another chapter. But the laws connecting pattern and human significance are seen at their simplest and most convincing in the decorative arts of the ancient Chinese, of which carving in Jade is the quintessence. Significant form is here based upon rhythmic contrasts between angularity and curvature, the simplest element of all design: it confers a power, rarely anywhere equalled, upon those uncanny masters in the linking of material shape and colour to an attitude of mind. The ritual Jade carvings of two and three thousand years ago exhibit in their stark austerity such a command over this linkage, that the most modern arts might well learn from them in all humility.

Another of the decorative arts, as seldom explored, is that of manuscript book-illumination perfected in medieval Europe and Persia; it too is peculiarly vivid in the emergence of an imaginative appeal independent of any apparent or verbal content. The geometrical patterning of a Celtic Gospel from the eighth century, the more naturalistic but still extremely formal and rhythmic

decoration of a French Book of Hours from the fifteenth century, are as abstract in their demands for imaginative creativeness in our approach—and as exquisitely repaying—as the ancient Chinese arts, and they are as independent of particular religious or mythological tradition. Our kinship with the artist is not through acceptance of the conventions of his time or race or any apparent content of his work, but through that imagination which responds to his insight into the most general pathos and exhilaration of human destiny.

Chapter 3

The Communication of Measurement in Modern Physical Science

I

Contacts between science and philosophy, or between science and religion, or between science and technology and craftsmanship, have never been impossible although they have not always been friendly. Contact between science and the more imaginative or even fantastic arts would seem unattainable. Such strange juxtaposition, however, I have already shown intention to suggest. For the arts of fantasy can only form an integral part of legitimate human endeavour if they imply that the imagination of an artist, expressed in a formal pattern of sound or words or material structure or design, acts by stimulating a responding imagination to definite and coherent purpose. Further, I have insisted that any scenes or material objects described in those arts need bear no simple relationship to the experienced sequence of our sense impressions of the external world. For instance, a fairy tale, or 'the music of the spheres' or 'the light that never was, on land or sea' are legitimate concern for this kind of communication by stimulus of the imagination, just as the façade of a commercial edifice might be the concern of a craftsman in the more obviously utilitarian arts, and murder may be the concern of a novelist or dramatist who scorns any imputation of fantasy. Now much of the concern of the modern physical scientist, atoms, electrons, atomic nuclei, electron-waves, etc., is essentially not of a nature to be directly known to sight, touch, or hearing. These 'things' are as far from being objects of direct sense-perception as anything imagined by the most fantastic of artists. If the latter justifies himself by the coherence of the communicated ideas to which his patterns give rise, where is he resembling and where is he differing from, the physicist whose view of the universe is a deliberately woven structure of ideas which also radically diverges from sense perception?

Without any move towards competing with the popularised versions of modern physics now filling so many works of deservedly

wide circulation, I will develop here very briefly the suggestion that 'pattern' and 'communicability' characterise the main lines of advance in the physical sciences of today. Elaboration of these two notions in understanding the imaginative arts might gain from explicit recognition that they also underlie atomic, electronic, and nuclear science, electrodynamics, and theory of relativity; while on the other side, the principle of Know Thyself might result in a recognition of aesthetic affinities by no means unhealthy to those of us who are working scientists.

II

Modern physics might well be regarded as study of the structure of matter and of the behaviour of radiation. A criterion for successful pursuit of the former study demands that analysis of material structures into atoms and molecules, and of these into nuclei with groups of associated electrons, must be capable of giving rise to verifiable prediction of the bulk properties of matter, mechanical, thermal, chemical, and electrical. Criteria for theories as to the behaviour of radiation are that the phenomena of light, colour, radio, X-rays, heat radiation, must become explainable by some single mechanism; the only mechanism so far successful has been the propagation of electric and magnetic quantities with a unique and universal speed which is accurately measurable. This speed exceeds that of the fastest material particles, as a limit towards which the latter can only approach. Within the scope of these two most general schemes, the structure of matter has been a prime example of 'pattern' since a Russian in last century arranged all the then known chemical species or elements into a two-dimensional framework. Written down in a table of horizontal rows and vertical columns, the chemical elements were found to repeat certain properties periodically, much as the harmonic properties of the notes on a piano keyboard repeat themselves at intervals of octaves. To form the gross substances which we distinguish by touch, smell, taste, etc., the affinities for chemical combining of atomic species are found to wax and wane with precise regularity throughout the periods of this table. The whole assemblage of empirically periodic patterns is now understood as manifesting the way in which successive electrons can become associated with atomic nuclei of definite mass: these additions proceed until one after another their possible federations into electrically and mechanically stable groups or sub-patterns are

exhausted. On a larger scale, chemically combined substances build a still more complex structure, capable this time of direct sense-detection, since there are only a strictly limited number of possible ways of electrically attaching aggregates of atoms and molecules to one another. Hence arises the visible structure of all crystals, with the certainty of prediction that a given association of atoms will at all places and all times, from the remotest geological to the present-day, exhibit the identical angle of inclination of each reflecting face to its neighbour.

Pattern in the structure of matter persists further down the scale of smallness beyond the atom, and has been investigated in the last two decades. We have been able to elucidate many of the nuclei of atoms around which the electronic grouping of the chemical order is built. Even the individual atom is far too small ever to come within the possibilities of sense perception, since a ten-millionth of a millimetre is too small a fraction of the wave-length of light for image-formation in any microscope for human vision. The electron itself is smaller by a thousand-fold. But the atomic nucleus, which is 'sun' to the 'planetary' electron, has a complex structure which the genius of Rutherford's school has made progress in unravelling with precision and an approach to certainty.

The extremely small in nature is clue to the extremely large: we even enquire why certain stars, far more massive than the sun, behave as they do in the ordered sequence which they present to our telescopes. The answer can be correlated with the statistical assessment of the structures of atomic nuclei in the interior of these stars, and thus the stage of energy liberation through which they are passing. In fact pattern of a homogeneous kind insists upon intruding, from the smallest inferred structures to the most massive and most distant in the sky.

On the other side of physics, the properties of radiation are linked not only between themselves but also with the material structures determined by the grouping of electrons in the periodic table of the chemical elements. The frequency of vibration, or the 'pitch', in the optical or X-ray spectrum of a hitherto unknown element, can be predicted from the position of the gap which its absence has left in the known pattern; so the missing chemical possibilities become filled in as they respond to computed expectations, whether finally 'run to earth' in a terrestrial laboratory or in the photographed spectrum of light from a distant star.

Throughout these parallel studies of matter and of radiation there has recently been running a strange duality, crossing and

recrossing what used to be the rigid boundary separating matter and radiation as the two subjects of physical science. The electron and the atom and the nuclear particles had seemed to be the bricks out of which the material universe was inevitably built, and radiation seemed to play the part of communicator between them, always propagated with the unique speed of light and of other electromagnetic waves. But lately it has become evident that the wave-pattern of light is also a characteristic of the motion of so-called material particles; further, that the property of acting as a minute projectile is not confined to electrons but is indisputably found in a beam of radiation impinging on a metal plate. So the complacent distinction between matter and radiation in the dictionary of early twentieth-century days has given place to a healthy agnosticism, which regards 'matter' as only intermittently free from properties previously ascribed solely to radiation, and vice versa. Matter is thus forced to take upon itself some of the aspects of empty space—fantastic nightmare for the materialists if any still survived. There is no doubt that both matter and radiation represent incompletely understood ways of approaching the same thing, although 'thing' is a word too ambiguous for comfort: a better term for conveying the status of the subject of physical discourse might be 'analysed substratum of experience' or 'pattern invoked in attempting to account for experience in measurable quantities'. But the ultimate pattern recedes the more diligently we approach: the finality of the views current in the nineteenth century is a lost vision, and we can only be grateful for release from the nightmare of a knowledge so complete as to be uninteresting.

III

It is not difficult to see this notion of 'pattern' in any portion of the range of physical enquiry, from atomic dimensions of millionths to astronomical dimensions of millions. But the other character, with respect to which affinity of interest was detectable between artist and scientist, was 'communicability'. Science is distinct from charlatanism because a known solution to a question is verifiable, and in its common language of experiment or calculation can be handed across the world as rigorously as from individual teacher to taught. As counterpart, communication by imagery from artist to responding reader or listener or beholder was the essential feature of art, but was variable from individual to individual.

The dominance of communicability in physical science was not explicitly realised until Einstein propounded principles of Relativity in 1905 and 1915. It now seems possible that the full implications did not dawn upon the philosophy of science until the work of Milne in 1935.

Essentially, the significance of these developments in the foundations of science is a recognition that no statement reporting any course of events is correctly formulated until the following condition is satisfied: we must know exactly what modification it will require in order to be equally true for some other observer stationed anywhere or moving in any direction with any speed. Knowledge is only of value to science if precisely communicable in a form which can be made independent of the separate behaviour of separated colleagues—even if the separation be as wide as the universe.

A simple example may serve to indicate the scope of this fundamental requirement. A set of observers both see and hear distant gunfire: shots fired at, say, ten-second intervals will produce sensations of sound at such intervals and sensations of sight of flash at similar intervals. But whereas an observer at the gun sees and hears almost simultaneously, an observer some miles away will experience his own version of the events delayed by a small fraction of a second for travel of the light wave and by several seconds for the far slower travel of the sound wave. There will be one distance at which an observer hears the first shot at the same instant that he sees the second shot. There will be a shorter distance at which another observer hears the first shot at mid-moment between seeing the first and second shots, and a longer distance at which an observer does not hear the first shot until after seeing the second shot. So the relations of simultaneity and of succession, foundations of the temporal experience of any individual, become interchanged according to the position of differing observers of the same set of distant events. Provided that the differently situated colleagues, whose scientific knowledge is to be guaranteed by its communicability, are stationary with respect to the objects of their common discourse and with respect to each other, the principles required in order to correlate their experiences are simple. They only need to make adjustment by computations depending on the speed of the tidings which reach them by sound or light. For the high speed of light (186,000 miles per second), astronomical distances and the motion of astronomical bodies, including the earth, are relevant: sight of a solar event takes about eight minutes to reach us, but

events on an outer planet, when that planet is on the far side of the solar system, take several hours to reach us. A sequence of changes affecting sun and one planet will appear to a particular observer to have been completed in the sun before being begun in the planet, but in another part of the solar system the contrary would be true. The outbreak of a 'new' star—or catastrophe to an old star—occasionally takes place at distances whence light has taken thousands of years to arrive here: with no event in the life-time of even our early scientific ancestors was the outbreak simultaneous, and yet in our own terrestrial sequence we say it occurs today. What is the dating of such events in the ordered and communicable sequence controlled by any space-time framework upon which the pattern of science can be woven?

IV

Einstein's 'Relativity' arose out of the more complex situation brought about when these time delays are not the only consideration, and the differing observers have their own finite velocities relative to the objects which they discuss and relative to one another. Einstein's discovery might be paraphrased by saying that differing observers will, according to their own velocities, assign different spatial 'lengths' and different temporal 'duration' to any one set of events. In fact Einstein and Minkowski replaced the older fixed temporal and spatial relations in the physical pattern of events by 'intervals'; an interval then dissects itself into temporal and spatial components according to the individual movements of each different observer, no particular dissection or assignment of time or length having intrinsic right over the others to be considered 'true'. It is with respect to such 'intervals', not to space or time alone, that laws of nature can become communicable. For the pattern of scientific knowledge appeared to Einstein not as a pattern of two different kinds of quantity, each having absolute existence in its own right as time without space and space without time; but as an infinitely variable partitioning of intervals into the space-like and the time-like.

It was not at first realised that this apparent complication was, in fact, a simplification of science; the epoch-making gain comes from the increase in communicability as a physical meaning is at last given to the 'transformation' discovered long before by the Dutchman Lorentz. Lorentz had been able to find the precise mathematical formulae by which one observer's motion alters his

estimates of length and time compared with those imposed by the motion of other observers: but before Einstein it had not been realised that these formulae actually represent the way in which one partition of 'interval' having a given degree of spatial and temporal character may always be replaced by some equivalent. The equivalents, as seen by Einstein, are simply different sets of partitions with more spatial and less temporal character or with more temporal and less spatial character, according to the motion of any observer. The resulting abolition of 'Absolute' time and space, or more strictly the abolition of our belief that the space-like or time-like have unique absolute meaning, gives rise to the name 'relativity'. But by the second quarter of our century it was possible to see that relativity was logically the requirement that scientific pattern should present natural law in completely communicable form.

In the last ten years a new method of analysing the way for laws of nature to become communicable has been developed by E. A. Milne, and if accepted it will possibly supersede the Einstein theory. This would not imply that Einstein was wrong in his generation, but that three decades of comment and criticism have enabled the older relativity to fulfil the function of all good science —that of making way for a better version: for no scientific theory is a creed but a good scientific theory may serve as stepping stone to a better.

Milne's work might be described, in terms of my view of pattern and communicability, by saying that he has discovered how the ordered sequence of sensations as events localised AT THE OBSERVER can adequately be utilised as a temporal foundation for scientific knowledge. Distance, velocity, and the Lorentz transformation, together with much electrical and optical and mechanical physics can then be traced as patterns built by combining the time-observations of different individuals. Einstein's merger of space and time into the single concept 'interval' appears in this later work to be a device for computation, which must not blur the ultimate significance of time as the primary characteristic of all measurable experience. Although Milne's researches are of the present day and in the controversial stage, some recognition of the primacy of our experience of events in a time-sequence seems likely to play a main part in future attemps to trace the origin of the patterns which are physical science. The feat of explaining the larger mysteries, such as the form and motion of the great spiral nebulae, appears by this means to acquire its first possibility of a rational fit into the biggest pattern of all.

V

These developments are all situated in the shadowy border-line between physics and the logic and Theory of Knowledge which enquires of physics its rationality. They are entirely independent of metaphysical views as to whether the scientist is creating pattern, like the imaginative artist, or discovering patterns which are inherent in external nature and complete without his intervention. At the level of my present discussion, more akin to a logic and a psychology of science and of art than to a philosophy of either, the metaphysical ambiguity passes us by and leaves us with this certainty alone, namely that the work of scientist and artist alike is the presentation of Form, Pattern, Structure, in material or in mental images. For the work of either to fulfil its function it must be communicable: the hearer, reader, or beholder of the work of art must in the end find coherence and feeling from the images aroused in his own mind, and the verifier of the scientific theory must be able to reproduce in his own mathematics and experiments the measurable facts communicated. The most obvious divergence between art and science is that any number of responding personalities to a work of art will find themselves creating any number of differing emotional patterns: on the other hand the numerical verification of a scientific theory is unique, all the different scientific minds converging upon identity. They invoke this identity as the only test that the communication of the pattern of electrons or atoms or time and space measurements is valid. The identity is possible because the subject of physical science is confined to the measurable, whereas the subject of the arts is qualitative, not quantitative. With this distinction guarded, the physicist and the imaginative artist might learn to see in one another the reflection each of his own aim, discipline, and method.

PART TWO

Examples of Imaginative Stimulus through Structure and Symbolism

Chapter 4

Introduction

The five essays following are intended as providing background and examples for illustration of the foregoing discussion of imaginative art. In Part I this subject was brought into contact with scientific notions of Pattern and Form and the criteria of Communicability. A distinction was developed between imaginative and representational arts; this suggests that in these five studies we need care little what concrete object is resembled by the shape of a carving or what narrative is told in a poem or drama, compared with a more important decision as to what such structures, visual or verbal, can convey in stimulating the imagination of beholder or reader by means of their Form. It is, therefore, no accident that the most abstract of Beethoven's music is placed in the same category with arts in which 'things' may sometimes seem to be represented but in which the stimulation of a state of mind is of greater moment.

The essay on Beethoven illustrates the least disputable application of these principles from Part I; for the dependence upon structural features is complete, and no 'subject matter' intrudes with any programme of representation from history or external nature. A confession of one hearer's feelings in imaginative response is no more than an incitement to infinite variety in the response of all other hearers. This essay, like some of its fellows, draws upon the unfamiliar in art-history although the artist has been for a time the most popular of musicians. For it concerns not the works for which he is best known but the final phase of his activity, in which he appears in a character seldom recognised by most of his admirers. Beethoven's last quartets afford much insight into a view of art as pattern communicating with the hearer's imaginative powers. I am making the unusual assertion that this phase of Beethoven's music is not only eminently hearable, but

carries the ordinary listener far further into the enjoyment of abstract form than the better-known work of this and other composers, while yet not abating but rather intensifying the element of feeling which has sometimes been falsely regarded as an antithesis to formality.

The plastic arts offer at first sight less facility for demonstrating the principles of imaginative stimulus by structure and form, for they degenerate so readily into the mere representing of objects. So two extreme examples are here selected, which may serve to bring craftsmanship in material nearer to the spirit of craftsmanship in sound, through recognition that images conveyed are not necessarily to be identified with objects pictured. The distinction between any 'thing pictured' and the image roused in the beholder may be illustrated by the way in which the second in the set of essays elects to approach the little-known subject of ancient Chinese carving in Jade. By investigating from Chinese archaeology and philosophy the intellectual and spiritual background of the artist, and then enquiring in what way these miniature sculptures have succeeded in appealing so vividly to the modern Western mind, we uncover an instance of mental attitude communicated across centuries almost independently of the particular representations fancied by the craftsman: animal, plant, mythical figure, or abstract geometrical design, can alike be the channel of closely similar communication. The ancient world saw in these carvings the dignity of the earth, the majesty of the heavens, the nobility of human character, so that contemporaries endowed Jade with the magic in which they believed. But for our love of the exquisite material no magic is needed, beyond uncanny fellowship with the long-dead craftsman whose exploitation of a sense of form causes our imagination to be roused again to his own conviction of undying values.

The far leap to the sculpture and architecture of Chartres Cathedral (third essay) is not a transition of mere caprice. The subject is one on which much both of technical and of religious character has been written; this essay is not an addition to either bibliography, but belongs to the present thesis because it attempts to connect the more memorable of the Chartres carvings with a far older formal tradition, the Byzantine. Modern critics are at last recognising that the Byzantine is not a mere decadence of classical art, and it is the imaginative and non-representational character of the Romanesque in its descent from the Byzantine which I am here claiming as important to the meaning of modern art—and even of

science. There is little in all European medieval enterprise which better illustrates the communication of an attitude of mind through disciplined patterns in which the abstract and the pictorial are everywhere interchangeable: we no more need to be adherents of the church under whose auspices Chartres was built, than we need to believe in the mythology of the carvers of Jade, and the archaeological guesses as to the identity of human figures represented are almost irrelevant in assessing the significance of the work to a receptive imagination.

Communication by form instead of by representation of external nature was perhaps not hard to recognise in abstract music, but is most difficult of all to accept in any literary art. After endeavouring to trace the principle in the more symbolic of ancient and medieval carvings, the possibility must be faced of extending it into arts where 'story' is unavoidable. Transition may usefully be made through considering a type of stagecraft in which 'story' is utilised but subordinated to structure, and both story and structure have symbolic significance. Ballet, along the lines taught to Europe by the Russians (fourth essay), has been much overwritten in the recent years of its fashionable success. The air of appealing to a transient craze has had the disadvantage of preventing any rational fit into place between musical, dramatic, and pictorial arts. But taking one example of extreme intensity and power, we here suggest that Ballet fulfils its most valuable function when it is non-representational, or when any 'reality' with which it elects momentarily to flirt is only a cloak for symbolic conveyance of a hint to fire the beholder's own imagination. Thus all good Ballet is at the same time fantastic and also strictly formal, however soberly concrete the little dramas of its stage mechanism. 'Petrouchka' is unique in the devastating frankness with which it defies the convention of 'real story', and reinforces from an unexpected quarter my thesis concerning the work of the imagination.

The verbal arts of poetry in verse or prose must, at first consideration, stand at the opposite extreme from music in the classification of representational and imaginative arts. For a sequence of words is expected to 'make sense'. So the ultimate significance of a poem becomes shackled by the mere apparent meaning of its words as they are determined by their explanation in any dictionary, whereas the imagination of a listener to music may come closer to the composer's mind because this bondage of apparent meaning is absent. It is clear that any inclusion of literature within the scope of the present view of imaginative arts must impose a

wide liberty upon poetry, of conveying by implication and stimulus to imaginings a significance not limited to the 'dictionary' meanings of its words. This responsibility has been honestly accepted by very few out of the enormous number of imaginative poets, and the liberty so often descends to licence that critics are uneasy. They feel themselves on guard against 'nonsense' and 'moonshine'; and are very ready to scent escapism in the faery or fantastic. The final essay discusses the extreme case of a contemporary, Walter de la Mare, as illustrating the criteria which can justify the use of verse as fantastic stimulus to imagination through its exploitation of formal structure.

The purpose of Part II will be fulfilled if these five essays not only emphasise features common in arts so widely scattered that readers familiar with any one of them may find novelty in another, but if their treatment and grouping reinforces the thesis of Part I. For the meaning given there to 'Imaginative art' in its relation to science is not convincing unless it facilitates the appreciation of ancient and modern works from music to very different arts and poetry.

Chapter 5

An Approach to Beethoven's Final Music for String Quartet

I

During the last three years of Beethoven's troubled life he ceased to compose for orchestra or piano the works by which he is generally known, and returned to the writing of string quartets. For fourteen years previously he had not attempted this intensely expressive form of composition, and his final development of it shows a Beethoven so altered that he seems almost to have passed into a new sphere of existence. Five quartets are the entire legacy from this remarkable phase; in some respects they are as isolated from his earlier work as from that of other composers, and they may well demand for their appreciation a special approach, though not necessarily a more learned approach. In fact, when listeners or players are inclined to dismiss these late quartets as unintelligible, it is often through the very difficulty of fitting them into the judgments already applied to his sonatas and symphonies. It may even have been obsession with the earlier works of Beethoven that drove a bewildered critic to label the final quartets 'dark with excessive light'. Certainly they are difficult enough to play, and, like all of the most permanent, they are not likely to yield lasting satisfaction to the listener until repeatedly heard; but the excellence of modern gramophone records has removed this bar to appreciation, and has allowed us to discover that nothing in the whole range of music more generously repays frequent rehearing. To accept the legend that these works are unintelligible is at least to disregard their extraordinary diversity; for no one who has ever taken the trouble to recognise 'sincere' music (whether light music or profound, gay or severe, classical or modern) need fail to find somewhere in them his own particular delight. Perhaps their secret is that under this diversity the only unity is of the vision to which their composer had attained, a vision with which we all are acquainted, but in fleeting moments only, and which we need to fix as permanent basis for the endurability of stormy existence. Recall that those

final years 1824-27 were, for Beethoven, almost unrelievedly clouded by total deafness, family disappointment, poverty, loneliness, frustration and despair: yet these five quartets contain some of the most exhilarating music ever written, albeit with a baffling mysteriousness about its flavour. This flavour is only partly due to the fact that Beethoven had lately become very preoccupied with styles and idioms resurrected from centuries earlier and as foreign to contemporaries as to ourselves. For we are arrested by the new suspicion of his having confronted decisively his destiny. He has a new air of mastery and penetrating insight even more provoking than that technical mannerism of combining the archaic and the revolutionary: it is perhaps this air which makes the composer of the final quartets unfamiliar and disquieting to those who know the groping Beethoven of the orchestral and piano works. The situation is subtle enough and allows room for many fresh individual attempts at discussion, including perhaps the present claim that these quartets are by no means inaccessible to the enjoyment of 'everyman in music': although the claim in this instance is bound to lack the solidity of expert musical learning, and must rest only upon the convictions of one untrained amateur, who merely owes much and because he loves much may possibly be forgiven much that would appear crude to the experienced.

If it is a novel confession that these quartets have contained a direct appeal to the ordinary listener, my classification of them is also unlikely to be orthodox. In fact the discussion may share with technical analyses little except the fact that no natural sequence can be made out of the published numerical order of these works, an order which appears to be fortuitous. It is well known now that the quartet in E♭ Opus 127 came first, Opus 132 in A minor next, then Opus 130 in B♭ with the fugal ending nowadays called Opus 133, then the Opus 131 in C♯ minor, and lastly the Opus 135 in F, with the alternative shorter ending for 130 written after all the others.

II

Any one of these quartets, except perhaps the 135, is able during a fine performance to persuade us that it is the greatest, but we find in the end that recollections of the 132 tend to emerge the most enduring. Accordingly I will suggest some comparisons with the 131, which Beethoven himself is alleged to have regarded as his best quartet. 132 in A minor has a singleness of structure depending essentially upon its first and last movements and their contrast to

what lies between. Both these have a spontaneous and romantic fluency and a most infectious insistence upon rhythm: a critic has used the picturesque description 'wildly regretful'. The two form the perfect prelude and aftermath to the longest, the central slow movement, the Canzona of tense devotional feeling which processes in all the stateliness of the ancient Lydian mode revived by Beethoven for this occasion. Beethoven's judgment outside his art was not always on a par with his musical intuition, and here as in most places where he heads a composition with words we may deplore the 'programme'. But in deciding to ignore the verbal label we might well retain in mind the one word Heiliger, since not even the awesome Sanctus of Bach's great Mass conveys more intimate revelation that a composer knew the tremendous implication of Holiness. The very simple solemnity of the chorale is heightened by the weirdness with which the medieval note-sequence strikes a modern ear, and twice the slowest portion reaches a point which would become unendurable if it were not broken by a recurring passage of exhilarating brilliance in dramatic contrast. The music seems to insist with overwhelming conviction that a man has met the greatest ordeal and caught a glimpse of some inward tranquillity with unshakable foundation. If emotionally and spiritually this is the highest peak of Beethoven's achievement, it shares with the rest of the quartet a sense of basing its appeal on subtle uses of rhythm; for instance, towards the end of the Canzona there appears an interpolated note to each phrase, imparting a lilt which strangely intensifies the solemn ecstasy as the volume of sound dies gradually: 'Fainter and fainter sounds the heavenly choir as it retreats, till nothing is left but the soft sighing of the wind' one critic has written—by no means a mere picturesque exaggeration of the poetic impression. The few bars of mysterious introduction to the first movement and the short passionate declamatory movement before the Finale and even the more detached Scherzo each play an essential part in balancing the Canzona against the powerful swing of the romantic first and last movements. It is arguable that their perfect sequence marks this quartet as the masterpiece, even on the technical ground of the composer's achievement in combining such forceful and original rhythmic contrasts.

The Opus 131 in C♯ minor breaks up still more radically the traditional pattern of movements. It has seven, and each passes into the next without a break, although two are not more than brief connecting links of a page-length in the score. Its musical

claim to greatness is often made out from the way in which each of these movements builds up towards and from a centre of gravity; but this architectural character we do not find more striking than in the 132, nor does the long central slow movement approach the Canzona in intensity and fervour. In fact the profundity of the 131 lies in the first two and last movements rather than in a centre. The character throughout is more diverse than in 132, although so skilfully balanced as not to seem heterogeneous. One might imagine that the composer was obsessed with a hard-won serenity's foundation in a multiplicity of conflicts, rather than any final attainment of tranquillity. The work begins with a slow fugue whose austerity is at first repellent, but which after many hearings exerts a fascination difficult to forget. Wagner found it melancholy but his opinion does not ring true; the fugue marches with a sense of inevitability and discipline but also of exaltation and nobility of character. At length its grave and measured meditation hangs arrested upon a single prolonged note, out of which rushes the second movement in a torrent of cascading tune. The monastic solemnity of the fugue is most exquisitely offset by this rapid second movement in which each instrument chases its fellows up and down ethereal flights whose exhilaration might well recall the dive of swallows. Both these movements glow bright with the glory of otherworldly vision that touched Beethoven in those last years. After a short connecting movement there begins the long set of variations which form the main slow movement; the magic of its demure opening statement over pizzicato 'cello again offsets perfectly the preceding few passionate phrases, and is one of the most memorable moments in these quartets. But the feeling is of a descent to earth, as surely as the corresponding central movement in 132 was an ascent to heaven. After the variations, another fast movement of extreme simplicity shows how Beethoven can recapture the gayest and most carefree mood, although its gossamer texture belongs to its period rather than to any revival of youthful jollity such as we shall find in the Finale of 130. In contrast, the short connecting movement before the Finale is of the most tragic intensity, and as passionate in its outcry as anything that the composer ever wrote: it leads into the tremendous battle-ground of the Finale, a movement achieving what was more crudely attempted many years before in the fateful conflicts of the C minor symphony. Few composers can have expressed such a whirlwind violence within the miniature texture of the string quartet—perhaps only Brahms in his quartet in C minor. But twice interpolated

at the height of the frenzied march are a few bars of long-held notes, with the hesitant change of time which is a queer characteristic of the profoundest moments throughout this quartet; this passage with its downward rush of one instrument against soaring rise of another is perhaps the most exhilarating of all the mysteries in these last quartets. It is an unforgettable culmination of the ecstasy which surges up and breaks through the tragedy of Beethoven, an apotheosis scarcely excelled in the whole range of music. After each appearance of this magical interlude the music flings itself back on the battling main tune; finally there is a coda in which the most forceful chords seem to assert a determined challenge, and after a brief slowing to a softened reminiscence it ends as tempestuously as it began.

III

The Opus 127 in E♭ is often recommended as the easiest or perhaps the 'least difficult' of the last quartets, and experts point to features in which it is less revolutionary and nearer to the earlier works, although it antedates the last of all by less than three years and probably overlaps its next successor. Certainly it presents the traditional four movements only, and they are of orthodox sequence in character, steady and formal, slow and meditative, delicate and rapid, shining and tuneful, for each of the four in turn. But this by no means reduces it to the commonplace or even the normal. In our own recollection it stands as the composer's last work of untroubled peacefulness: the subsequent quartets may seem to suggest a happiness only attainable through storm and conflict, as in the 131, or through the monastic concentration of the quietist, as in the 132, but the happiness of the 127 is idyllic and carefree. It is the happiness of a child, of the experiencing of spring or of summer sunshine in a cloudless sky. Not even in the B♭ symphony is anything nearly so radiant to be heard. Consider only the breathless chords at the opening, and the overflowing excitement of the solo violin's trill which then dissolves into the graciously flowing tune. Both this movement and the equally happy Finale are full of repetitions so gratuitous as to suggest a spontaneous delight of the composer at his own craftsmanship, unable to quit the phrases which he can only have written to his own most exquisite joy. It is perhaps the greatest miracle of these later works that such manifest mood of the carefree should shine forth from the mind of a totally deaf musician. The lengthy medi-

tation of the slow movement is again unclouded by the tension of the other quartets, and even the curious wistfulness of the third movement does not modify the impression that its airy delicacy is only a gossamer transcription of the same innocent mood. At the end of the Finale, however, there comes a change, and the sunshine gives way to a hint of the mysteriousness which dominates the subsequent works: de Marliave speaks of a 'frémissement d'elves' and it suggests a spirit from the magic shadows of a forest rather than any ghost of dismay or grief or even questioning. But even this ecstasy of tiptoe peering is still childlike, and before the end there recurs the multiple repetitioning of phrases which already in this work had betrayed the composer's reluctance to let the lovely moment escape.

Opus 130 in B♭ I find the least among these giants, not by any inferiority in structure or sincerity or mood, but because it seems less of a unity. Characteristically this work is the only one which I often split up and play in fragments of one movement, whereas in the other three great quartets any detached portion seems lost without the entire composition. In fact the movements of 130 might have been separate little tone-poems, and one is not astonished to learn that the infectious dance section was originally intended for another composition, and also that Beethoven was readily persuaded to abandon the enormous fugue (afterwards published as Opus 133) as too long for the Finale of this work. The alternative Finale was written after all the quartets were finished, and is sometimes considered rather unworthy, but it only conveys a pleasing reminder of the early Beethoven—jolly, capricious, and boisterous. It is the younger Beethoven familiar in many of the works for piano or orchestra, who was as irrepressibly perky as Haydn. That 'after-thought' of a Finale is not the only point at which other composers occur to our mind in hearing this particular quartet: is it a heresy to suggest that the massive and rather portentous first movement contains glimpses of the rich tone colouring which we imagined only Brahms could impart to string chamber music? And surely the Andante Scherzando with its irresistible appeal of delicately changing rhythms—the gem of the whole quartet—is the most graceful interlacing of grave and gay ever conceived by anyone but Mozart himself? It has nevertheless a flavour of the whimsical and belongs to the nineteenth century, or even the twentieth, more than to the days of the greatest of all musicians. The tiny Presto might be an exercise by some unknown, writing to extend the virtuosity of a violinist, and sounds more like

a delightful piece reserved for an encore in a solo recital than part of a long quartet. Even more isolated from the remainder of the work is its one tragic moment, the slow Cavatina: it is probably the most desolate of all Beethoven's writings, and has a simplicity which is quoted even by those who avoid these late quartets. This lovely fragment is only excelled by the similar but happier short slow movement of the last quartet of all, the Opus 135 in F, which movement we often find to be the only memorable portion of that work. The 135 seems otherwise capricious, diabolically skilful, even suspect of cynicism, the perkiness of the early Beethoven become self-conscious.

IV

I suggest that any attitude to these late quartets will be confused unless we decide whether we are to talk about musical skill or about the wider concern of human response to environment. When we judge them as monuments of composition, we feel they lack the uncanny perfection which leaves us aghast at the set of quartets which Mozart dedicated to Haydn and which nothing ever surpassed, a perfection the more striking because attained with a simplicity which makes Beethoven at his very greatest look clumsy. Further along musical history, all Beethoven's art appears like that of monochrome drawing in comparison with the rich colouring of Brahms's quartets, which miraculously possesss much of his symphonic variety of tone even when there are but four instruments to combine. I cannot escape the feeling that Beethoven was not as finished a musician as Mozart or even Brahms or Bach; but these final quartets do compel a conviction that nowhere among musicians was there ever one who more intimately knew the loneliness which confronts humanity, and at the same time became aware of a divine serenity which can at great price be attained. Somehow Beethoven must have caught the heavenly vision which passes understanding, and the claim upon us of his last quartets is that they repay constant companionship by transmitting a trace of that vision.

A critic's longest life's labour would be well expended if he could see and convey more precisely the situation of Beethoven among his works, but acquaintance with much more than music would be needed and the mind of the specialist is often narrow. One question in particular recurs to me with insistence, but is not likely to be solved: Beethoven's last quartets are works of vision

and have vital relevance to the destiny of those who listen to them, but was Beethoven himself possessed of the conquering tranquillity of that vision or did he only realise that it was a consummation which others would be able to attain? Did the deaf and disappointed invalid experience the exaltation of climbing those ethereal heights, or was he limited to making known his discovery that for some listeners such exaltation would come within reach? It is possible that, like other artists, he could only save others but not himself, for example Rembrandt who painted the very character which was lacking in his own nature. The contrast between Beethoven's music and his disastrous and wretched human relationships leaves this suspicion only too well founded.

Chapter 6

Ancient Chinese Carvings in Jade, and their Appeal to the Modern Western Mind

I

Books and articles on jade carvings and other Oriental crafts are commonly issued for collectors, antiquaries, art critics, or scientific anthropologists, with the assumptions that a specialist outlook will be both necessary and also sufficient for appreciating works of so remote a civilisation. Each assumption may be wrong. An expert bound by Western tradition may find more difficult than an unprejudiced stranger the task of realising the intentions which depended upon the mental background of so distant a craftsman. On the other hand, I propose to suggest that this barrier is not impenetrable, and that neither artist or connoisseur or scientific investigator, nor the untrained enquirer, need regard as inaccessible the mind of those who created and loved the art of jade. Perhaps there is an insight discovering strange kinship where worship gave rise to fine workmanship. Consider that during three thousand years, while our own ancestors have been preoccupied with phases of civilisation ranging from druidical rites to railways, there have never been lacking some Chinese who regarded jade as possessing peculiar magic and as conferring character and nobility upon those who cherished it. To the modern Western mind the interpretation might well be different but the facts unaltered; there is only no longer any need to invoke a supernatural explanation. For in contemplating and handling these stones we are not merely soothed by the marvel of their subtle colours, their lustre, and their touch, but we begin to realise our relationship with the distant artist who believed his years well spent in their carving; the imagining of an imperturbable poise and a serenity, which the exquisite things seemed to stimulate at the other side of the world hundreds or thousands of years ago, is created again in a living English mind. By nothing more mysterious than this inheritance, the piece of jade becomes a talisman to convey the permanence of

loving skill and taste, an ennobling and consoling reminder in the modern whirlwind as it was under the most war-scarred and bloodstained of Chinese dynasties.

II

The most familiar jade to be seen in modern England consists of small and highly ornamental objects for domestic use, commonly in the various shades of bright green which characterise one variety of one only among the minerals classified as 'jade'. There are bowls, cups, vases, etc., and personal ornaments such as pendants, and more rarely the wine-vessels, libation cups, incense burners, etc., of the traditional household devotions. There are many intriguing little sculptures carved in realistic or in conventionalised form—the dragon, the tiger, horses, birds, fishes and insects. The sight of all these in museums or in the windows of antique dealers is apt to be misleading: we conclude too hastily that all jade is a stone of vitreous lustre and greenish colours ranging up to an emerald brilliance, apparently chosen by Orientals for those minor occasions on which Europeans might use glass or porcelain or copper or silver and various precious stones.

But that conclusion would miss the profoundest significance of jade and of the Chinese regard for it. The makers of those fanciful green ornaments were often merely trifling with their skill; while the product sinks to the European taste of recent centuries, the taste which has chosen to import a species of Oriental art and to accept it indiscriminately as pretty. On the whole, this phase is not such as to have roused strong feeling in its original craftsmen or its later dilettante owners. Examples were made in thousands in the eighteenth and nineteenth centuries, and are camp-followers to the fine art which culminated in the reign of Chien-Lung (1736–1795). That art was sincere though often over-florid, and the finest of its jade epitomises one of the master-periods of all decorative technique. The carving demonstrates, once for all, how the severity of geometrically set angles and straight lines may be combined with skilfully conventionalised curves of animal or plant life. But it tends to lack the dignity of the simpler and older designs, which used a different kind of jade, often not green at all, long before the first Ming emperors of the fourteenth century A.D. These older jades, which I shall refer to as archaic, have only recently been studied in the West, and mainly through the researches of Dr. Laufer into the connections between art and magical beliefs.

It was after the thirteenth century A.D. that a newer stone largely replaced the original material with which the ancient magic had first been associated. However, the dark and subtly veined jades of two and three thousand years ago are not unconnected with the bright greens of the last half-dozen centuries: the continuity may be traced by examining both archaic and modern objects which were not merely ornamental but were designed in terms of religious ritual for the welfare and safety of individual and community. The making of sacrificial vessels and furniture for the domestic altar was always strongly controlled by tradition, requiring that they should be carved from a stone which possessed many qualities of the original jade. Similarly in royal and public institutions and State ceremonies, the symbolic insignia had to be of a material which in some way might inherit the archaic dignity or sanctity. For this reason, even among the most flamboyant shapes which the modern Chinese carved in his Burmese green or white, there persisted ideas and intentions traceable to another jade from a different region and an older world.

We begin to regard those archaic jades with new understanding when we recognise that they were intended as symbols of some primitive belief, and were only unconsciously works of art. Among the most characteristic are ceremonial axe-heads, stone swords, and the six strange objects associated with reverence to heaven, earth, and the north, south, east, and west. These were made of jade from the time of the Chou dynasty (1122–249 B.C.) or earlier. Their stark austerity of design, and the variegated and subtle dimness of their material, produce a very different impression from the lavishly decorated ceremonial objects of a later age. In the older dynasties, an aimless skill in technique had not yet tempted the craftsman into mere display, such as the imitation of bronze vessels or even of metal chainwork by cutting from a single block of jade, which seems to have been a frequent exercise of virtuosity in later times. Indeed, of the archaic symbols of heaven and earth and the universe the two most impressive consist merely of a large circular disc with a perforated centre, and a cylinder enclosed in a nearly rectangular prism. While so many works of art can express no more than the ephemeral characteristics of their time, there appears an age-resisting perfection in these very ancient objects of jade, unforgettably refreshing as varying illumination lights up the blue and red and yellow veins in the dark green or grey or black stone surface. As survivors from a craft still in its unsophisticated stages, it is possible that they would not have appealed to

the West before this twentieth century; but in our contemporary reaction against the flamboyantly over-decorated we have reached a position to appreciate their simplicity. It is the Homeric simplicity, which so many centuries between have failed to maintain. The austere shapes carved before the second century B.C. seem as perfectly adapted as their sombre colours to the quiet profundity of thought and dignity of character expressed in the poetry and philosophy of that period. Perhaps nothing but ancient Egyptian sculpture impresses so sternly our current and tardy realisations that the greatest art may also be the simplest.

III

In enjoying the actual craftsmanship, one soon begins to ask whether the Chinese were unique in cherishing so long the art of jade carving, and why their tastes in material and design fluctuated around the original purposes inherited from antiquity. These questions need first some enquiry as to what jade really is, and whence it was obtainable at the various historical epochs we have mentioned.

Jade, so-called, may be any of at least three mineral species. These are all included in the large class of silicates of lime, magnesia, soda, and alumina, which contain impurities of iron, chromium, etc., and are classified as pyroxenes and amphiboles. They occur in various igneous rocks. Jadeite, a pyroxene, is a sodium-aluminium silicate, owing its many shades of green and other colours to the impurities. It has a vitreous lustre when polished, and is more often granular than fibrous in structure. Nephrite, the other mineral most commonly known as jade, is a calcium-magnesium silicate with its colouring again due to traces of iron and other oxides. These colours are often darker and more subtle than those of the vivid jadeite, but there are varieties known as sea-green, lettuce-green, grass-green, moss-green, spinach-green, and the green of the feather of a kingfisher's wing. The delicate gradations shade into one another as the proportion of some metallic oxide becomes greater. An endless sequence also occurs in reds, purples, browns, and greys. Nephrite is an amphibole, of an oily lustre rather than vitreous and of a more fibrous texture than jadeite. In fine-grained structure both these jade minerals form oblique rhombic prisms, but the pyroxene has a cleavage angle of 87 deg. compared with 56 deg. in the amphibole. Some of the blackest jade belongs to a third mineral, chloro-

melanite. The main crystalline differences are probably due to pyroxene-bearing rocks having more rapidly solidified from their liquid origins.

The three jade minerals are sometimes difficult to distinguish from sillimanite, which is of purer composition, from certain felspars which are softer, from emerald, which is more transparent, and from green garnet, which is denser. In the more extreme colourings they may even be confused with blue lapis-lazuli and turquoise, green malachite, and a red-brown pyroxene called rhodonite. The dull waxy fracture of both jadeite and nephrite is a fairly convincing test.

In speculating on the Chinese artist's choice of materials, it is significant that only the very earliest jade carvings were from a stone indigenous to China. Nephrite occurs mainly in Turkestan and also in Siberia, New Zealand, and Alaska, while jadeite is chiefly found in Upper Burma and also in Tibet, and possibly Mexico and South America. There are rarer European occurrences, chiefly in Alpine regions; these have, after much argument and research, been definitely proved to be native and not imported. Transported materials have given rise to occasional finds of jade objects among prehistoric remains in Germany, France, Belgium, Italy, Switzerland, England, and in Egypt and Mesopotamia.

The archaic jades of China before the Han dynasty (206 B.C.–A.D. 220) seem to have been carved from genuinely native nephrite, probably obtained near the capital of the Chou dynasty (1122–249 B.C.). But from that time until the thirteenth century A.D. most Chinese jade was Turkestan nephrite, sought for especially in the boulder-carrying rivers of Khotan and Yarkand, which flow from the Kuen Lun mountains. On the other hand, from the thirteenth century onwards Chinese jade was often Burmese jadeite imported from the Kachin region by Yunnun traders, and later particularly from Mogaung. This last is the source of the green stone of common Western acquaintance with jade.

IV

We thus have to recognise that at least one race treasured the traditions of using jade for two thousand years after having ceased to obtain any supplies of it within the bounds of their own country. Their arduous and costly importations of nephrite from Turkestan and jadeite from Burma must be contrasted with the comparatively meagre use of the material in countries where it was locally

available. Most primitive peoples pass through a stage of making stone implements, and many have discovered the jade minerals to be conveniently tough and suitable for grinding into durable shapes. Examples of such usage occur in the several regions which we have mentioned as sources of jadeite or nephrite, and in other places where the material became available through glacial transportation or the migrations of culture along primitive trade routes. But except in New Zealand, where nephrite had considerable popularity for the carving of miniature figures and amulets, and in Mexico, where votive tablets suggest that jadeite was chosen for ritual purposes, the jade minerals seem not to have been particularly revered outside China. They have merely shared temporary and local fluctuations of favour with marble, jasper, rock-crystal, emerald, amethyst, topaz, chalcedony, onyx, agate, etc. For instance, in ancient Babylonia, the cylindrical seal used for commercial and State intercourse is found in all these stones, and among them in jade, but without any sign of the latter being specially regarded.

This is essential in understanding the Chinese, for the vexed question of possible contact in culture migration must not be neglected. There have been suggestions that the early Chinese civilisations show evidence of being derived from Western or nearer Eastern sources: the Sumerian cities of Babylonia, the proto-dynastic Egyptians, the less-known civilisations of the Indus Valley, have all been regarded by some authority at some time as parent cultures. But while it is true that nephrite or jadeite has been known in India, Egypt, and Babylonia, we cannot avoid the fact that these civilisations show no deliberate choice of jade over other materials for purposes associated with reverence to nature and the powers of personality. Within China, on the other hand, the earliest jades that have survived their three or four thousand years from the Shang-Yin dynasty already begin to suggest that exclusive regard for these minerals; the philosophical, religious and artistic attitude of the Chinese was already concentrating its symbolisms upon jade in a manner quite different from anything that we meet in primitive civilisations of earlier or later time. Hence, whatever conclusions may emerge as to pioneer acquisition of the stone itself, the aesthetic discovery seems to remain Chinese.

With regard to a culture diffusion in the opposite direction, from Chinese to non-Chinese, the finds in Central America and in Europe have again been argued as possibly indicating that other peoples copied faintly the Far Eastern devotion to this material.

V

The foregoing facts raise an intriguing problem when we ask what impulse maintained this thirty centuries of enthusiasm for jade carving. We can only reach the fringe of this question at present, but if certain suggestive directions were explored, the enquiry might contribute not merely to the understanding of one minor Chinese art. For in finding the relevant mentality to be common in the East but rare or absent in the West we approach some of the most widespread links between the arts and the beliefs of mankind.

To begin with there are elements common to Chinese and to other primitive religious imaginations. Notably there is the protective property ascribed to certain objects such as charms, amulets, the tiny coverings made to close the eyes of the dead, and other intimate possessions of personal and sacred significance. These notions of magical protection were nowhere more highly developed than among the Chinese, with the possible exception of the ancient Egyptians. But in China such traditions were reinforced by an acute sensitivity to the material beauty of the jade minerals. This created a combination of appeals which no other substance in no other civilisation has been able to command.

Another characteristic might be classified as poetical or perhaps philosophical rather than religious, and appears more intensely among the Chinese than in the matter-of-fact Egyptians; it is the tendency to associate material symbols with phases of human temperament and morality. From regarding carved jade as such a symbol, it was a short step for the Chinese to maintain that contemplating or handling jade conferred upon the owner something of the purity, steadfastness, nobility, and serenity, of which each little sculpture had become an emblem or embodiment.

In understanding any ethical aspects of the minor arts, it must be remembered that the Chinese revered the dignity of supreme craftsmanship and the patience of prolonged effort, as among the intrinsically good qualities of a life well lived. This appreciation became almost instinctive when trained, and the Chinese shared it with other peoples in other ages, for instance, the illuminators of manuscripts in the European monastic times and in Persia. But the status of these little carvings was enhanced by a uniquely Chinese addition to the visual aesthetic judgment—the appreciation of tactile and auditory values in an artist's material. Whether the jade was the oily nephrite or the icy jadeite, to handle and feel

central perforation; some, like the present example, are decorated in low relief, some are plain and have nothing to distract from the sole beauty of dim shadings in dark grey, green, and purple. The Dragon ring may be an extreme form of Pi in which the relief decoration entirely submerges the original shape. The Kuei or pointed blade is more often than not decorated with cross-hatching or (as here) with circular grains; various of its uses have been traced, including that of talisman given by the emperor to his bride.

Of the two remaining objects, the black knife is possibly a jade talisman used in conveying imperial orders to subordinate officials, while the curved knife is probably an emblem for ritual purposes only. The combination of straight lines slightly diverging in the shaft with the faint curvature along the blade is typical of the effective use of the most simple elements of design, a skill in which the earliest carvers of jade seem to have something new to astonish all subsequent ages of decorative art.

PLATE 1. JADE HORSE FROM THE HAN DYNASTY
Victoria and Albert Museum photograph

PLATE 2. BROWN AND WHITE JADE TSUNG
Victoria and Albert Museum photograph

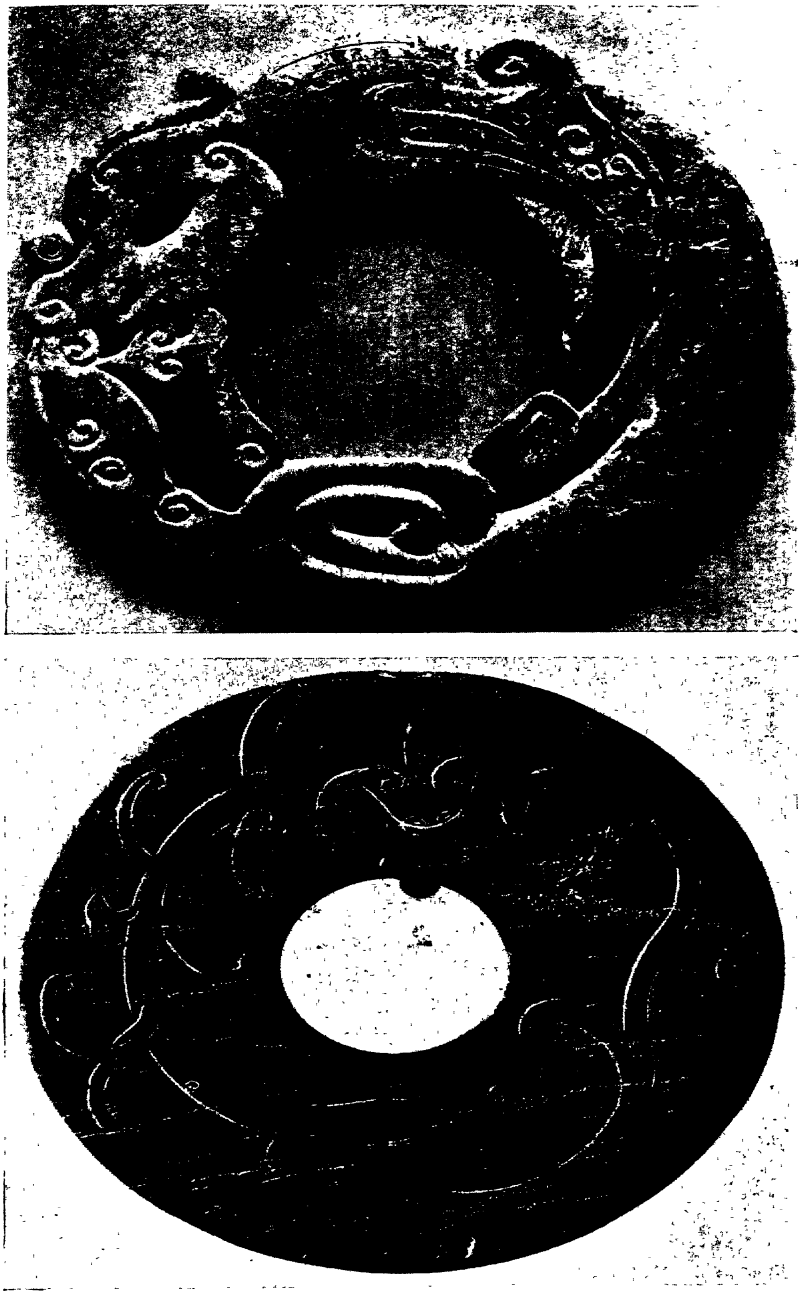


PLATE 3. JADE DRAGON RING AND EMBLEM OF HEAVEN
Victoria and Albert Museum photographs

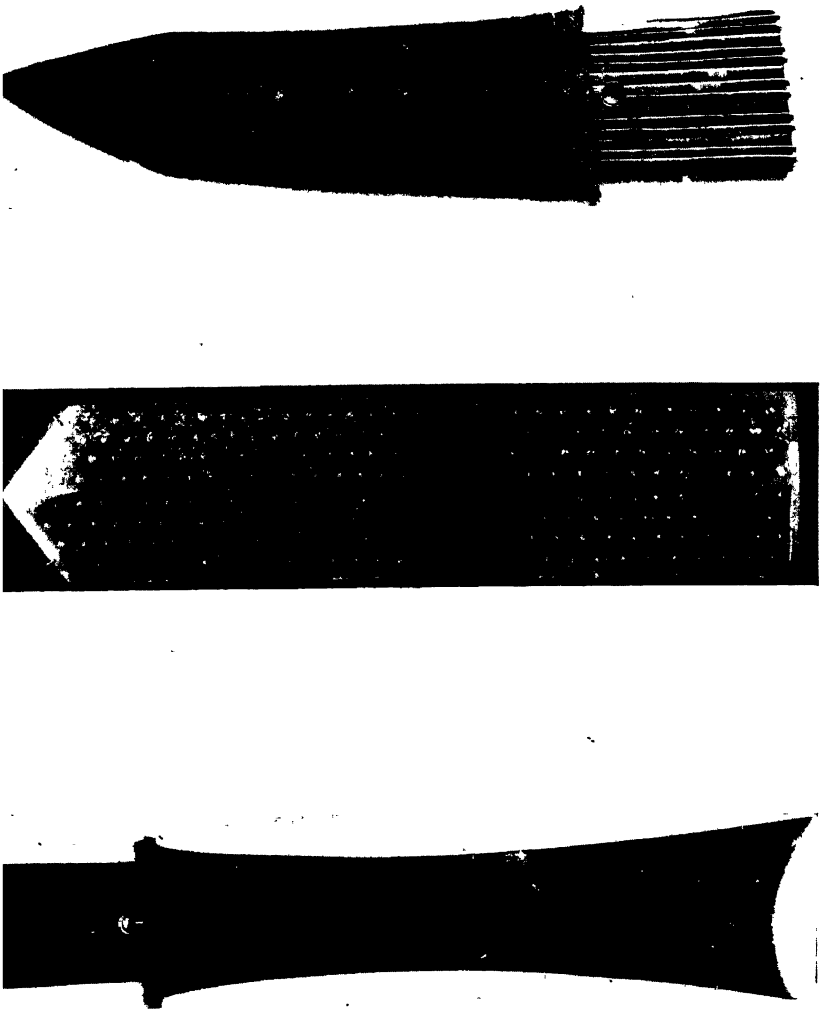


PLATE 4. SYMBOLIC BLADES OF JADE
Victoria and Albert Museum photographs

Chapter 7

From Byzantine Manuscripts and Ivories to the Gothic Sculpture of Chartres

Cathedrals of Northern France have often shocked any Anglo-Saxon visitor who had been contented with the more kindly dignity of English Gothic. The fantastic skeleton of flying buttresses at Amiens, Beauvais, Le Mans, or Bourges, associated with the monstrous height of the Continental Gothic, together with the overpowering forest of a thousand statues covering the later façades at Reims and Rouen and elsewhere, might create an impression of disquiet or even of nightmare, when compared with cathedrals nearer home. In the end it is possible to be left unsatisfied by monstrosity, and perhaps Chartres outlasts some others in recollection for the very reason that its most significant portions were built long before any taste for the Flamboyant had developed; also the urge to outdo some neighbour in size or complexity had not yet become a serious motive when its last rebuilding was planned, so that a singleness in purpose adds to an impression of strength conveyed by the restrained dimensions and decorations of the main fabric. Nevertheless it is a striking and even intimidating experience to run the gauntlet of the strange sculptures which cluster round the oldest or more Romanesque doorway at Chartres; years afterwards one remains haunted by the cold enigmatic questioning with which the faces of the colossi seem to look down from the West front upon a modern mortal venturing between their ranks.

I propose in this note to draw attention, more pointedly than in most accounts, towards an association of such feeling with the artistic ancestry of these colossi which are among the oldest large sculptures in any French cathedral. There are hints seeking the peculiar strength of this art in a development of Byzantine from Syrian, Persian, and Celtic decoration, and I shall suggest that these hints might well be followed up more closely. It may turn out that the Romanesque aspect of Chartres is not to be regarded only as crude germ of the later medieval or Gothic, but as an immortal vision from the earlier or 'Dark' ages, exhibiting a spirit which survived and outshone the terrors of a stormy thousand years.

Apart from its sculpture, and its unrivalled glass of 175 lights from the twelfth and thirteenth centuries, Chartres Cathedral is remarkable for a general austerity in its architecture strangely mingled with an occasional intensity suggesting the emotion of a fanatic. In fact, the present writer was sent there by a shrewd Hungarian scientist who said to him: 'If I were to revisit Paris for only three days I would always go away and spend one of them at Chartres—without doubt that place was built by a madman.' It is true that the buttresses, more soberly massive in relation to the general anatomy than usual, have a disturbing uncanniness in odd features such as their fantastic wheel-spoke supports. It is true that the delicate filigree gallery running behind suggests the queerest revulsion from those enormous austere projections of stone. It is true that one is left aghast at the audacity of mixing a motif of clustering vertical lines in the truncated towers above the South porch. Throughout the building runs a weird harmony in discord, suggesting that those who completed the main structure at various stages possessed an almost pathological insight into the dreams of their earlier masters. Neglecting some post-Renaissance reliefs in the interior, and the famous solitary sixteenth-century angels who dominate the surrounding country from the roof, the sculpture consists mainly of two kinds. (*a*) The several hundred figures of very Romanesque appearance decorating the West portal; these survive from the twelfth-century building that perished in the fire of 1194 and were probably carved between 1110 and 1190. (*b*) The 705 figures of the North porch and the 783 figures of the South porch; these are of rapidly matured Gothic character and were probably carved between 1205 and 1270. This sculpture of the two porches shares with figures from other French cathedrals some of the most gracious genius of the thirteenth-century Gothic, and for that reason is less startling; I will briefly touch upon some of its features before turning to the earlier Romanesque of the West front, which is quite unique, and which raises such intriguing problems of the spirit of modern and of pre-Gothic art.

In the sculpture of the thirteenth-century porches, a perfect naturalism comes within sight for the first time since ancient Greece: the superbly characterised figures have no longer the exaggerated head and slender elongated body of the earlier Romanesque, when an effigy was as verily a decorated pillar as a human representation. The new conception was of statues in their own right, and their draperies flow in human lines instead of conventional parallels. Nothing surpasses them before Michelangelo

PLATE 5. COLOSSI FROM THE XIIth CENTURY WEST PORTAL AT CHARTRES

Photograph by Tel of Paris

PLATE 6. COLOSSI FROM THE XIIth CENTURY WEST PORTAL AT CHARTRES

Photograph by Tel of Paris

or since the Athens of Pheidias. Less well known are the hundreds of tiny scenes running round the inside of these porches, for instance the woman opening a book in charming grace of diligence and care, and the calm symbolic Deity in the act of creating Adam. Scores of legends and symbols, of all the virtues and vices, and the terrific crises of martyrs' life and death, are recounted in these minor sculptures which border both porches, and between are tiny miniature reliefs of a vivacity and grace unsurpassed in any age; while, dwarfing them, each colossal saint or apostle or legendary knight has a portrait individuality which reinforces the little effigy of his life's adventure carved in miniature between his feet and the column at which he stands. Not all the figures carry calm and grace: among the carved stories are some of the most sinister devilries even of the medieval imagination. For instance a fiend, carrying over his shoulder a woman whose hair trails behind his monstrous clawed feet, is outdone in sheer malice by his neighbour who with ironic gentleness is leading away a queenly figure by a paw laid along her cheek.

In contrast to this throng of perfectly proportioned creatures from the thirteenth century, vivid in their anatomical realism however preposterous in their legend, the strange figures carved before 1194 on the West portal are at first repellent in their apparently uncouth and conventional stiffness. But they are very far from lifeless: on the contrary, when in pursuit of certain suggestions we trace this earlier art back to Oriental traditions and try to realise the attitude of mind of the pre-Gothic sculptors, their curiously convincing power may be found to have very human origin. We begin to appreciate an artistic vitality which expressed itself through symbolic and formal rather than representational technique, but which can be as compelling as the more naturalistic arts of classical, Gothic, Renaissance, or modern times. We illustrate these groups of colossi from the twelfth-century West door, together with one typical from the hundreds of minor figures, here Pythagoras bending intently over the mathematics which absorbed him.

It matters little who were those colossal kings and queens. Possibly they were intended as the traditional ancestors of Christ. But the artist or artists had an uncanny sense of timeless watchfulness, as strong as had also been expressed in the tomb sculptures of ancient Egypt. The calmness of Egyptian monuments may suggest a uniformly cruel superiority to the affairs of ordinary mortals, while the calm of the Romanesque colossi at Chartres suggests instead

a wide variety of very ordinary temperaments become powerful through having learnt to overcome a hard world: they remain sympathetic because that learning was only attained by a discipline of self-mastery. There are nineteen surviving of these colossi, though originally there must have been twenty-four; they range from pensive to petulant, contemplative to threatening, but each contributes his or her intense personality to the unescapable question: 'Can you endure the terror we have known and attain the Vision Splendid which only our strength of mind can give?' Between these colossi are countless tiny figures representing zodiacal and calendar sequences, symbols of arts and sciences, biblical and legendary heroes. Almost hidden by the statues are the carved shafts with myriad minute figures climbing among stone leaves and branches. Under the feet of the larger statues are symbolic monstrosities such as the ape with a toad on its chest and a dog under its foot while a dragon stretches its head towards the toad, or a little queen whose hands caress the plaits of her hair and the tail of a serpent. Above all these is the huge relief of the Christ, of whom this unusually austere countenance has been called 'the most haunting image of Him that exists'.

A clue to the impression created by these earlier sculptures is provided in several hints from the literature which we list in the bibliography: a purpose of this note is to urge a closer investigation of such hints by all those who recollect Chartres or who have loved other medieval masterpieces in this and other countries. We recognise that the carvings of the West front are earlier than most accepted Gothic, nearly a century before the North and South porches and still further ahead of the best-known cathedral statues of here and abroad: I have so far adopted the safe term of Romanesque for them, as they can be compared with their few predecessors and contemporaries which lead the Romanesque towards the Gothic among the decorations at Saint Denis, Vézelay, Autun, and Cluny. But Romanesque can be a grossly misleading term unless its peculiar non-Roman constituents are scrutinised. Although it is an exaggeration to think of a Cluniac style as postulated by Viollet-le-duc, there is no doubt that a spirit in religious art spread from the South and East as far as Chartres while the twelfth-century church was being built there, and that in an important centre for that spread the Abbots of Cluny owed much to exchanging missions with Antioch. Craftsmen in ivory and book-illumination were spreading northwards and westwards in Europe from a Constantinople which had trafficked much with

PLATE 7. COLOSSI FROM THE XIIth CENTURY WEST PORTAL AT CHARTRES

Photograph by Tel of Paris

PLATE 8. COLOSSI FROM THE XIITH CENTURY WEST PORTAL AT CHARTRES

Photograph by Tel of Paris

the intellectual Renaissance of Bagdad. Textiles from Persia had been influencing profoundly the Byzantine carving which had developed most exquisitely in ivory diptychs and plaques and caskets, and Byzantine illuminated MSS. from the ninth to twelfth centuries have much in common with Persian art and even with the amazing Celtic offshoots which spread a radiance from Ireland to St. Gall. There are in the available literature many photographs of the Byzantine ivories, Celtic MSS., and Persian designs which inspired so much of European art, and some of their winged monsters are obviously of the same genus with the huge flying creatures surrounding the Christ on the West portal of Chartres. But some of the Rhenish developments of Byzantine art were no further north-east of Chartres than the Cluniac Romanesque with Syrian ancestry was south-east of it, and we need no longer be astonished that, as one commentator has said, the pre-Gothic sculpture of Chartres is as Eastern as a Gregorian chant. Perhaps we shall some day decide that it links the Oriental to the Gothic as surely as archaic Greek statues link the ancient Egyptian to the classical: though it is possibly undesirable that the Byzantine and Romanesque should become as artificially fashionable as was once the fate of the pre-classical Greek.

In detail, the enlarged heads and thin elongated bodies of these colossi are not merely ascribable to incompetence or even mainly to the deliberate blending of sculpture with architectural structure; their distortions belong to the tangled artistic history which I have quoted. They are as Byzantine as the long parallel-line foldings of their draperies, the pearled borders of their mantles, the extraordinarily interwoven complexities of their pedestals. Above all there is the haunting irony of expression which gives the 'age-long dignity of the Byzantine' and which came only from that unprecedented mingling of severe classical with enigmatic Oriental temperament. In truth the Byzantine artist was preoccupied with spirit and not with physique, and he gained in mystery and tense strength of mind what he lost in never attempting the naturalism of the Greek or the Gothic or later art: his crudity is at least as honest as that of the ultra-modern. A writer listed in our bibliography has even suggested that the Byzantine, being non-representational art concerned rather with the ideas invoked by a symbol than with portraiture of a living object, is the real companion to the 'significant form' of Clive Bell or Roger Fry or of carvings by Eric Gill. The suggestion provides a novel starting point for the present-day to re-examine the despised arts of the

Dark Ages; the 'queer' illuminations of Oriental MSS., or carvings of ivory screens and caskets, may take upon themselves a share of the ethereal and the sublime when followed to their logical conclusion in those supermen and women of the West portal at Chartres. In the thousand years between classical and Gothic, human nature was as hard driven as at the present moment in struggling to survive the darkness of a perilous passage in history, and the art of that age shows traces from which much might be derived for the mid-twentieth century.

PLATE 9. COLOSSI FROM THE XIIth CENTURY WEST PORTAL AT CHARTRES

Photograph by Tel of Paris

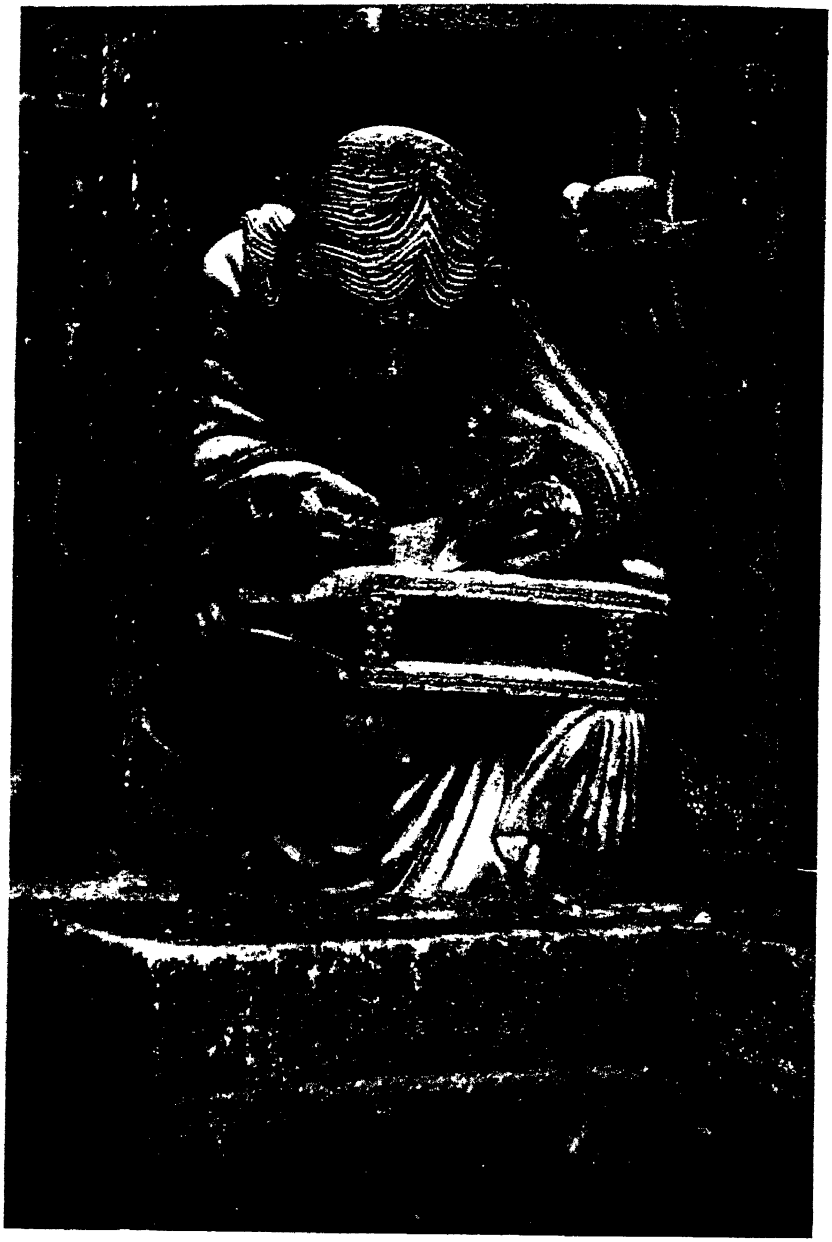


PLATE 10. PYTHAGORAS MINIATURE FROM THE XIIth CENTURY DECORATION AT CHARTRES

Photograph by Houvet of Chartres

Chapter 8

After seeing the Russian ballet 'Petrouchka'

Petrouchka is a fantasy expressing a certain tragic situation which arises from time to time in the history of most individuals. There are few modern people who do not occasionally suffer acutely from the disease which Petrouchka symbolises, the disease of possessing an over-sensitive consciousness of ugliness and deficiency without the strength or the wit necessary for escape. A subtle combination of musical, dramatic, and pictorial arts, woven into that formal pattern which makes up a Ballet, is able to expound this tragedy very simply and very completely. Its simplicity penetrates more deeply than any literary representation tied by the inadequacy of words, and its emotional expression in orchestration, dancing, gesture, and colour has the intensity found only in Russian art.

Ballet being an art without words, it is not forced to obscure the universal application of this tragedy by insisting upon the accidental circumstances of any one human being. It thus is enabled to exploit to the full the advantages of an art which can surrender itself to the fantastic. In fact Petrouchka is an outstanding example of the symbolic nature of the creatures represented in a genuine Ballet. They are themselves the types, not mere individuals, and appropriately in Petrouchka the chief characters are puppets, of whom the most vivid and significant can thus symbolise the momentary or occasional experiences of any person. Both sides of a common aesthetic paradox are thereby fulfilled, a work of fantasy and imagination being also a work of a brutal realism. As in other classic examples of this peculiar art, the humans in the story are only minor characters forming a background or a comic relief, and against that background an animated doll suffers at the hands of his fellows and of the magician master who is his devil.

According to this plan the tragedy of the too-sensitive automaton has to play itself out in the midst of a cheerful comedy of the simple-minded Russia of 1830. The scene is a fair in old St. Petersburg, with street performers of every kind competing in their attempts to entertain a crowd. The movement of every group

in this crowd exhibits Michel Fokine's inventive genius at its best, and the continuous blend of dancing and posing to Stravinsky's intricate orchestral score is apparently haphazard but exquisitely shaped in its subtle rhythms. When the popular carnival is at its height we notice that attendants are drawing the crowd's attention to a little canvas booth which evidently covers some sort of show; presently a very old man in fantastic garb, posturing with a flute outside this tiny theatre, marshals the spectators and clears a space, and the canvas is drawn back. His show consists of three little boxes, in each of which is a life-sized doll, the crude and savage 'Blackamoor', the Dancing Girl of a painted and gaudy prettiness, and Petrouchka, a lanky and cadaverous creature whose permanently strained expression contrasts with the blank and unintelligent stare of the other two puppets. He alone has unfortunately been endowed with something like a soul. In response to the old magician's incantation, the three dolls emerge. They display in a desperately agile set of movements the crude and mechanical kind of life which their maker has succeeded in conjuring up for the delight of the street mob.

The second scene is behind the stage of the old charlatan's little theatre. The dolls are being put back in their boxes, and we see the unhappy Petrouchka thrown and kicked into his cell and left to solitude as the door is shut on him. There begins one of the most difficult of all parts for a great dancer to play; he must express, by every frantic leap and posture and contortion of a wooden and doll-like awkwardness, the desperation and loathing with which he reacts to his slavery. The senseless damage in his attempts to escape, or to destroy the mocking portrait of the magician on the wall, convey with Stravinsky's music a spiritual devastation beyond words, and for which any other art than Ballet would be inadequate and futile. We then see the Dancing Girl, and it soon becomes obvious that any attraction to Petrouchka which she might have felt is turned to terror and repulsion by his mad attempts to reach in her the only consolation he can imagine. The scene in the cell of the Blackamoor is quite different; this more bestial creation is not worried by the highly developed sensitivity which tortures Petrouchka. He is obsessed merely by a coconut with which he first plays lazily and contentedly. In a primitive reversion of mood he becomes suddenly uneasy and then terrified, ending by worshipping his coconut as the only deity he can find. This involves a set of movements contrasting extremely with those of Petrouchka but equally demanding of the dancer's skill; he passes from a

sensuous rolling on his back, swinging his toy on his feet with the music, to an agitated capering which works him up to attack the fetish with fury, and finally to the rhythmic prostration with which he is driven to appease the mystery which seems to defy him. The Dancing Girl comes in, trying to escape from the uncomfortable longings of Petrouchka, and she becomes fascinated by the monstrous negro. After a long time, even the latter's dull imagination is caught by her dances and he joins her in a grotesque attempt to imitate her gracefulness. The fantastic *pas de deux* is interrupted by Petrouchka, who has at last managed to break out of his cell. His awkwardness and self-conscious misery is driven to an insane pitch by the sight of the other two together, but he is easily thrown out by the brute strength of the negro.

In the final scene of the Ballet we return to the crowd in front of the marionette theatre, but it is now a late evening of falling snow and the revellers dance with a more violent gaiety in keeping themselves warm. The cheap and simple entertainers are joined by a man exhibiting a dancing bear. The coachmen and nursemaids and other humble folk dancing together are reinforced by a crew of late wanderers from some fancy-dress party, grotesque in enormous animal heads and masks.

Suddenly the canvas of the magician's little theatre bursts open and the three dolls rush out; the negro and the Dancing Girl have tired of Petrouchka's discontent, and the former chases him into the crowd and cuts him down with his monstrous toy scimitar. The revellers are instantly stricken to immobility and then rush in horror to where the dying Petrouchka is struggling to explain. They crowd round him as Stravinsky's music beats out the last frightful gesticulations for his awkward wooden limbs. In Ballet the crowd is the silent counterpart of a Greek chorus, and at this point their movements express perfectly the vaguely sympathetic stupidity of the human herd. Not quite certain whether a murder has been done or whether these creatures were only the marionettes which they had applauded earlier in the day, they send for the town guard and drag out the magician. The old reprobate mocks their bewilderment and picks up the corpse to demonstrate that it is only wood and sawdust.

But after the mob has drifted away, subdued and a little uneasy, the magician starts to trudge back to his deserted theatre dragging the broken Petrouchka behind him. A change in the music expresses the misgiving which suddenly seizes him as to whether the doll which he animated was nothing but an automaton. Misgiving

gives way to terror as a climax in the orchestra accompanies the appearance of a second Petrouchka above the roof of his canvas building, a threatening and vengeful ghost of the smashed figure which the old man is dragging. He drops his burden and scuttles away, and the gesticulating monstrosity on the roof is appeased and soon lolls over the canvas as immobile as the broken doll left lying on the deserted stage.

Chapter 9

Fantasy and a Real World, in the Poetry of Walter de la Mare

It is a common assumption, in many fields of human enterprise, that fantasy implies a lack of realism. For poetry, more simply than for other arts, it may be possible to resolve some of the uncertainties in the use of these two very ambiguous terms. In attempting to decide whether realism may or may not be credited to a poem called fantastic, the purpose may be better served by regarding the means through which we are enabled to appreciate certain phases of the art of writing, rather than by formulating definitions which would inevitably be very complex.

Consider what happens as soon as we come to criticise a poem whose structure or rhythm or symbolism plays a large part in the total stimulus to the reader's imagination. The case becomes interesting when this significance inherent in structure is strong compared with the significance inherent in any mere superficial meaning of the words of the poem: for this superficial meaning could have been obtained from a paraphrase of verbal equivalents which might be entirely devoid of imaginative stimulus. In extreme instances some absurdly impossible subject-matter may still exert a strong effect upon the reader through the manner and structure of the verse, just as it also might through the manner in which an imaginative picture of the same subject was painted.

When the contents of a poem thus appear to lose all contact with sense-experience, the term fantasy becomes applicable. In many poems such fantasy degenerates all too easily into mere caprice: but there are others in which a profound significance for human liberty or bondage, or terror or exaltation, may be genuinely and vividly conveyed by the form and structure, even though piecemeal analysis of each sentence might yield mere triviality. Even nonsense verses might convey through their structure, as can a piece of music, a genuine significance for human feeling, and whenever this occurs the property of realism cannot be denied to such fantasy.

I proceed to consider the imaginative poetry of Walter de la Mare as an example of verbal fantasy which has in some quarters been dismissed with contemptuous reference to moonshine and dreaming. It is an example which gains in understanding when we attempt to resolve this ambiguity between the fantastic and the real, and which itself can help us to discover some of the criteria which confer legitimacy upon other arts of imaginative character.

Commentators who accept uncritically the antithesis between realism and fantasy have implied that de la Mare, like the ostrich in legend, tries to evade facts by refusing to face them, and is an escapist who hides from a painful world by creating unreal worlds of the imagination. 'An opiate giving sleep and visions, but which does not give vision and does not awaken' is a description by which so responsible a critic as I. A. Richards stigmatises the work of this poet. He suspects in de la Mare 'an impulse to turn away, to seek shelter in dream, not to stay out in the wind' and 'a reluctance to bear the blast' of the modern intellectual environment. Mr. Richards' modern intellectual environment may not be quite the same as mine, although he too is apt to claim for it a scientific origin. I propose to adopt a more scientific, a strictly empirical, criterion; because it is not science but a particular metaphysical interpretation of science which seems to have interested Mr. Richards. When a form of art exhibits preoccupation with dream or other fantasy, I suggest that it is most relevant to ask whether our sympathetic understanding of the more acute crises in human feeling has been heightened by that art, and our impulse towards practical courage in such crises thereby stimulated. If this test—a severe one—is satisfied, the ambiguity to which I referred is resolved, and the art is essentially realist in the effect of its structure or its symbolism upon the imagination, however trivial or nonsensical might be the dictionary meaning of the verbal medium through which the pattern enforces its real impression.

The quotations which I now select from de la Mare may in this way suggest that the course of his genius has not been a retreat from profound feeling, but more truly a pilgrimage entering at every stage into the most inescapable of life's uncertainties. To begin with, it is the part of the sternest realism to see an alternating succession of fear and tranquillity as a common feature in human experience. Here are two poems by de la Mare in which these two fundamental states of mind are inherent: each example is as truly a fantasy as is a piece of abstract music or a symbolic carving

or the work of some painter obsessed by light rather than by material objects.

> Who, now, put dreams into thy slumbering mind?
> Who, with bright Fear's lean taper, crossed a hand
> Athwart its beam, and stooping, truth maligned,
> Spake so thy spirit speech should understand,
> And with a dread 'He's dead' awaked a peal
> Of frenzied bells along the vacant ways
> Of thy poor earthly heart; waked thee to steal,
> Like dawn distraught upon unhappy days,
> To prove naught nothing? Was it Time's large voice
> Out of the inscrutable future whispered so?
> Or but the horror of a little noise
> Earth wakes at dead of night? or does love know
> When his sweet wings weary and droop, and even
> In sleep cries audibly a shrill remorse?
> Or, haply, was it I who out of dream
> Stole but a little way where shadows course,
> Called back to thee across the eternal stream?

The second poem suggests that tranquillity, as well as terror, can be conveyed as convincingly by fantasy as by description of some actual situation.

> Sweep thy faint strings, Musician,
> With thy long lean hand;
> Downward the starry tapers burn,
> Sinks soft the waning sand;
> The old hound whimpers couched in sleep,
> The embers smoulder low;
> Across the walls the shadows come and go.
>
> Sweep softly thy strings, Musician,
> The minutes mount to hours;
> Frost on the windless casement weaves
> A labyrinth of flowers:
> Ghosts linger in the darkening air,
> Hearken at the open door;
> Music hath called them, dreaming, home once more.

The mood is supremely quietening, but the verse is too perfect in pattern to dull the edge of a reader's sensitivity, so it is far from

being merely soporific. It is matched by the beginning of the same poet's Sleeping Beauty:

> The scent of brambles fills the air.
> Amid her folded sheets she lies,
> The gold of evening in her hair,
> The blue of morn shut in her eyes. . . .

Or by the end of Nod, his fantastic shepherd with sheep-dog Slumber-Soon:

> . . . His are the quiet steeps of dreamland,
> The waters of No More Pain.
> His ram's bell rings 'neath an arch of stars,
> Rest, rest, and rest again.

An art which communicates fear as vividly as tranquillity offers no channel of easy escape from reality. Further, the poet's imagination can scarcely be shirking the hard or sordid, for instance, when his imagery has conjured up the prisoner on trial for life, listening to overwhelming evidence:

> . . . Voice after voice in smooth impartial drone
> Erects horrific in his darkening brain
> A timber framework, where agape, alone
> Bright life will kiss good-bye the cheek of Cain . . .

Vision of death, as in the earlier quotation Dream of death, conveys something no less real in poignancy than an actual description of civilisation's brutality:

> No flower grew where I was bred,
> No leafy tree
> Its canopy of greenness spread
> Over my youthful head.
>
> My woodland walk was gutter stone.
> Nowhere for me
> Was given a place where I alone
> Could to myself be gone.
>
> In leafless Summer's stench and noise
> I'd sit and play
> With other as lean-faced girls and boys,
> And sticks and stones for toys—

Homeless, till evening dark came down;
And street lamp's ray
On weary skulking beggary thrown
Flared in the night-hung town.

Then up the noisome stairs I'd creep
For food and rest,
Or, empty-bellied, lie, and weep
My wordless woes to sleep:

And wept in silence—shaken with fear—
But cautious lest
Those on the mattress huddled near
Should, cursing, wake and hear . . .

Thus sometimes a sober report of material fact plays an equal part with fantasy, in no way superior as regards realism since both fact and imagination can equally be expressed by saying

. . . In the forests of the mind
Lurk beasts as fierce as those that tread
Earth's rock-strown wilds, to night resigned . . .

Another pair of quotations reinforces our decision that the imaginary, the symbolic, or the fantastic, may be vehicles of realist communication from poet to reader not inferior to those arts which confine themselves to the mundane or material. Take a supposed story by de la Mare, of actual captivity:

. . . Last dusk, at those high bars
There came, scarce-heard,
Claws, fluttering feathers,
Of deluded bird—
With one shrill, scared, faint note
The silence stirred.
Rests in that corner,
In puff of dust, a straw—
Vision of harvest fields
I never saw,
Of strange green streams and hills,
Forbidden by law. . . .

This carries as sharp but no sharper poignancy than another poem

of captivity of which the purely metaphorical significance is given away by the last word in the second line:

Why did you flutter in vain hope, poor bird,
  Hard-pressed in your small cage of clay?
'Twas but a sweet, false echo that you heard,
  Caught only a feint of day.

Still is the night all dark, a homeless dark.
  Burn yet the unanswering stars. And silence brings
The same sea's desolate surge—sans bound or mark—
  Of all your wanderings.

Fret now no more; be still. Those steadfast eyes,
  Those folded hands, they cannot set you free;
Only with beauty wake wild memories—
  Sorrow for where you are, for where you would be.

The genuine realist's mingling of disquiet and peacefulness is always present in any sensitive reactions to the major phenomena of nature. It is in accord with the balance already noticed between fact and fantasy that these reactions may be conveyed by the imagery of a fairy tale as vividly as by any description of sense-experience. Everyone must re-create in his own separate imaginative idiom the impressions to which a fantasy may give rise, but the beauty and the subtle intimidations of an early morning will probably be a common background to most recollections of the next poem.

I heard along the early hills,
  Ere yet the lark was risen up,
Ere yet the dawn with firelight fills
  The night-dew of the bramble cup,—
I heard the fairies in a ring
  Sing as they tripped a lilting round
Soft as the moon on wavering wing.
  The starlight shook as if with sound,
As if with echoing, and the stars
  Prankt their bright eyes with trembling gleams:
While red with war the gusty Mars
  Rained upon earth his ruddy beams.
He shone alone, low down the West,
  While I, behind a hawthorn bush,

Watched on the fairies flaxen-tressed
  The fires of the morning flush
Till, as a mist, their beauty died,
  Their singing shrill and fainter grew;
And daylight tremulous and wide
  Flooded the moorland through and through:
Till Urdon's copper weathercock
  Was reared in golden flame afar,
And dim from moonlit dreams awoke
  The towers and groves of Arroar.

The mysteriousness of dusk in a deserted estate has aroused in most people an equally intimate mingling of the uneasy and the reposeful, and that subtle mood is relived by many readers of the following fantasy.

From out the wood I watched them shine—
  The windows of the haunted house,
Now ruddy as enchanted wine,
  Now dark as flittermouse.

There went a thin voice piping airs
  Along the grey and crooked walks—
A garden of thistledown and tares,
  Bright leaves, and giant stalks.

The twilight rain shone at its gates,
  Where long leaved grass in shadow grew:
And black in silence to her mates
  A voiceless raven flew.

Lichen and moss the lone stones greened,
  Green paths led lightly to its door,
Keen from her lair the spider leaned,
  And dusk to darkness wore.

Amidst the sedge a whisper ran,
  The West shut down a heavy eye,
And like last tapers, few and wan,
  The watch stars kindled in the sky.

Finally the sea also yields up its sense of populating the imagination with a crowd of thronging life: this piece of fantasy also shows the flicker of impishness characteristic of its author, a valuable

safeguard against the portentousness which lies in wait for the unwary experimenter in the symbolic arts.

Down by the waters of the sea
Reigns the King of Never-to-be.
His palace walls are black with night;
His torches star and moon's light.
And for his time-piece deep and grave
Beats on the green unhastening wave.
Windswept are his high corridors;
His pleasance the sea-mantled shores;
For sentinel a shadow stands
With hair in heaven, and cloudy hands;
And round his bed, king's guards to be,
Watch pines in iron solemnity.

His hound is mute; his steed at will
Roams pastures deep in asphodel,
His Queen is to her slumber gone;
His courtiers mute lie, hewn in stone;
He has forgot where he did hide
His sceptre in the mountain side.
Grey-capped and muttering, mad is he,
The childless King of Never-to-be;
For all his people in the deep
Keep, everlasting, fast asleep:
And all his realm is foam and rain,
Whispering of what comes not again.

The repeated and yet subtly variegated rhythm emphasises the element of form and pattern, which needs in fantasy to be even more rigorously disciplined than in representational arts. It must, in fact, be as hardly wrought and as delicate in perfection as the mathematical formulation of physical science: for if intimacy with human feeling is the pre-requisite without which fantasy cannot attain realism, severe discipline in the mode of expression is the only salvation from mere caprice, and without it the images stimulated can only flicker and fade.

Fairy tales such as we have quoted from de la Mare are for the child-like but the child-like of all ages; it seems to be a law of nature that any vision of reality aroused by fantasy is—like the kingdom of heaven—only accessible to a certain simplicity of mind. The tragedy of outgrowing this in superficiality and

sophistication is the subtlest to which the whole of humanity is condemned: perhaps it is the only tragedy of old age, for this poet has expressed the dignity and charm of the elderly, in the following as much as in 'Nod':

A turn of head, that searching light,
And—was it fancy?—a faint sigh:
I know not what; there leapt the thought,
We are old, now—she and I.
Old, though those eager clear blue eyes,
And lines of laughter along the cheek,
Far less of time than time's despite
To one who loves her speak . . .

But he is extremely sensitive to the grown-up inability to catch the youthful vision, although his own insight retains more of the child-like clarity and honesty than has been given to most of us.

I search in vain your childlike face to see
The thoughts that hide behind the words you say;
I hear them singing, but close shut from me
Dream the enchanted woods through which they stray.
Cheek, lip, and brow—I glance from each to each,
And watch that light-winged Mercury, your hand;
And sometimes when brief silence falls on speech
I seem your hidden self to understand.

Mine a dark fate. Behind his iron bars
The captive broods, with ear and heart astrain
For jingle of key, for glimpse of moon or stars,
Grey shaft of daybreak, sighing of the rain.
Life built these walls. Past all my dull surmise
Must burn the inward innocence of your eyes.

Even when the child-like perceptiveness is not outworn or thrown away, its vision is fragile, and is vulnerable to the crudity of sophisticated disturbance. Possibly the poet has this in mind in an early fantasy:

Bring not bright candles, for his eyes
In twilight have sweet company;
Bring not bright candles, else they fly—
His phantoms fly—gazing aggrieved on thee.

Bring not bright candles, startle not
  The phantoms of a vacant room
Flocking above a child that dreams—
  Deep, deep in dreams—hid in the gathering gloom.

Bring not bright candles to those eyes
  That between earth and stars descry,
Lovelier for the shadows there,
  Children of air, palaces in the sky.

Perhaps the ancient Chinese possessed, more fully than any other artists, a skill in exploiting the imaginative; and from any study of Chinese craftsmanship in the minor arts we learn that the child-like and the profound are not so far apart as immature sophistication might suggest. So from the world of nature as fairy-tale de la Mare makes no very drastic transition when his verses begin to symbolise the same world as inescapable fate:

. . . Very old are we men;
    Our dreams are tales
  Told in dim Eden
    By Eve's nightingales;
  We wake and whisper awhile
    But, the day gone by,
  Silence and sleep like fields of amaranth lie.

Here again the fantastic is the most direct and convincing of communications. The continuity of life, together with its discontinuity for each individual, is subject-matter for any realist, but the implications of the responsibility thus imposed upon any generation are most penetratingly expressed in fantasy. For responsibility towards the past,

. . . Even if thine own self have
  No haven for defence;
  Stand not the unshaken brave
  To give thee confidence?
  Worse than all worst 'twould be,
  If thou, who art thine all,
  Shatter ev'n their reality
    In thy poor fall.

A realist's responsibility towards the present:

For all the grief I have given with words
May now a few clear flowers blow,
In the dust, and the heat, and the silence of birds,
Where the friendless go.

For the thing unsaid that heart asked of me
Be a dark, cool water calling—calling
To the footsore, benighted, solitary,
When the shadows are falling.

O, be beauty for all my blindness,
A moon in the air where the weary wend,
And dews burdened with loving-kindness
In the dark of the end.

A final quotation suggests responsibility also towards a future; the sense of contact between every artist and every appreciator of art throughout history can even give rise to this faint ghost of a creed, emblem of all fantasy that has attained a genuine realism:

. . . Look thy last on all things lovely,
Every hour. Let no night
Seal thy sense in deathly slumber
Till to delight
Thou have paid thy utmost blessing;
Since that all things thou wouldst praise
Beauty took from those who loved them
In other days.

PART THREE

Historical Failure to maintain a Balance between the Scientific and the Imaginative

Chapter 10

Introduction

In Part I, I have discussed some of the contrasts and likenesses between the aims and methods of physical scientists and imaginative artists. The scientists were found to be correlating the concepts which arise from measurement, into patterns capable of communication. Any final form of the pattern was required to be independent of individual behaviour of differing observers. The artists were likewise building forms and patterns in their several media of expression, but in order to communicate stimulus towards a creative response which must differ from one individual to another. In Part II, I traced this element of imaginative response through a somewhat unfamiliar variety of artistic achievements. The most obvious sequel would be to call at once for scientists and artists to regard each others' labours with a new interest and sympathy which might well grow to enthusiasm, and to call for a planning of future education towards that end.

Unfortunately both the history of civilisation and the temperament of certain historical figures must be disillusioning, if we expect any success from throwing science and art together without warnings against the mixing of inflammable materials. To superpose science and art profitably requires not only recognition of the restricted similarities in aim and method already discussed, but the confronting of dangers from which only historical investigation of past misfits can be an adequate guard.

There have been eras in which an educated man could only live up to his standard if he were at the same time a poet and a philosopher and an experimental or mathematical researcher. In certain Oriental civilisations this effort towards synthesis was not merely a measure of the primitive state of the relevant sciences, and an encyclopedic mind was genuinely cultivated. The net result in advancement of science was often amazingly productive in

quantity but poor in quality. There results the stigma that trespass between art and science implies dilettante blindness to great responsibilities, and we shall not escape it unless we confront and understand the reasons for these early failures.

In the case of Leonardo da Vinci there was an additional maladjustment, equally relevant to the present day. His peculiar temperament, in some aspects epitome of all misfits between science and society, calls for a detailed investigation *ab initio* which occupies the whole of Part IV. But Part III is concerned with a more widely dispersed range in the historical relations of science, art, philosophy, and religion, in such environments as were capable of fostering their coincidence down to the present era.

The history of science, like that of any other major human activity, may be investigated for its own sake. This is not my present purpose. The following studies do indeed cast a light upon scientific stagnation in civilisations which regarded science highly and encouraged scientists with a policy of generous if capricious reward; we have to notice why the resultant progress was small compared with the progress of fewer scientists in civilisations far more contemptuous of them. But the Moslem and Chinese workers and writers can also serve a more intriguing purpose, as miniature model of the strength and weakness of the scientific and artistic minds when these mutually interpenetrate; medieval Oriental history may be found to reveal certain warnings as to lack of equilibrium between the logical and the imaginative, warnings no less serious for today because of the primitive stage of science from which they come.

The Chinese epitomise the tragedy of scientific conservatism; to exhibit this in detail, an investigation is included of those works of art which were astronomical instruments in A.D. 1279. When the Far East was faced with problems which invited rapid advance, it responded with an attitude of mind more suited to conferring imperishable dignity and nobility upon decorative arts which I have discussed elsewhere in this book. The misapplication brought centuries of stagnation, from which the Chinese scientists might have been saved by consenting to utilise the Moslem contacts obtained at great cost. There are few tragedies of culture more exasperating than the final sterility of those continent-wide pilgrimages of which I give some account below. It becomes possible to see why most ancient Chinese science, superior all over the world in qualities which depended on the patience of its artist-technologists, remained obstinately stationary until the impact of

a younger and livelier European science caught its frozen dignity in the seventeenth century.

The Moslem researchers, deliberately ignored by the Chinese in spite of painfully won acquaintance, came from a scientific culture more youthful which had flourished amazingly but briefly after the ninth century. Some novel aspects of the story are told in the essay on the Bagdad mathematicians. These hundreds of scientific writers in Arabic, Persian, Syriac, and Hebrew, known to the Renaissance in Latin version, are also to be written down as a historic failure to achieve what lay open to them: the warning is once more against lack of balance between logic and imagination. It was not the deliberate conservatism of the Chinese which restricted the multitudinous advances of the Moslems to mere detail, where radical reconstruction was urgent, but an equally crippling blindness with an aesthetic basis. The scientific pattern inherited from the Greeks was aesthetically satisfying so long as general and communicable laws of nature were not sought; so the labour of centuries and many hundreds of treatises were expended in tinkering with an ever-growing complexity in the interpretation of nature as a system of circles.

These Oriental civilisations represent diligence of scientific activity, sterilised through exploiting unwisely and uncritically the kinship between logical and imaginative senses of design and pattern, and through failing to recognise the communicability which is the essence of modern science. In modern science and philosophy and art we pass to the other extreme of refusing to allow contact between the imaginative and the logical. A first step towards learning the lesson of the medieval would be to see the place of science in relation to other mental disciplines, and for this purpose the by-ways of non-European history are more illuminating than much conventional history of post-Newtonian science.

Between the Renaissance and the modern era there is in the philosophy of Spinoza a most unsuspected parallel to the Oriental misfitting of logic and imagination. Spinoza, more than any other character in history, foreshadows that compound of mystic and logician which must some day reconcile the scientific with the imaginative—true superman to come. But his work has had little direct influence outside the academic circles of philosophic history, because he bound himself to a geometrical formality of exposition without restricting his subject of discourse to topics susceptible of such treatment. The aesthetic attraction of the Euclidean form of argument was as fettering a chain to his ideas as the aesthetic

appeal of Ptolemaic astronomy was a millstone about the neck of the Moslem scientists. The novelty of regarding him as an artist, with a philosophy ruined by compression into scientific instead of imaginative form, is highly unorthodox: the essay here included on Spinoza is intended to drag his memory out of its imprisonment in academic circles, and to suggest reflection on the limitations of scientific technique for philosophy.

Critique of the past with no constructive contribution for the future is always invidious, and so a final essay in Part III concerns Symbolism: through recognition of the large part played by symbolism in our intellectual pursuits, there may conceivably come some day a reconciliation between aesthetic, scientific, and religious attitudes to experience.

Chapter 11

The Persian and Arab Artist-mathematicians of Medieval Bagdad

I

There have been scattered moments of history in which science and art have flourished not only side by side but together within the same personalities. The individual instance of Leonardo da Vinci is of such importance to understanding the scientist's and artist's reaction to environment that it is investigated in detail in some later chapters. The European Renaissance contains many other examples, but compared with Leonardo these tend to illustrate only less vividly the contrasts which are in him outstanding; so it will be useful to look further eastwards, where the European tradition of specialisation and of divorce between imaginative and logical enthusiasm never penetrated, and where a man was a mathematician and a poet and possibly a prince without being an aberration. The facts of history in these regions are little known to conventional western study, and much of the following essay is necessarily a first exposure of bare fact: the suggestions just now put forward in the introduction to Part III are a focus towards which my tale of the Bagdad mathematicians may serve to converge supporting evidence.

The peculiar scientific mentality relevant to contact with the arts was found scattered over various Oriental civilisations; for instance in the Alexandrian culture which inherited the Greek tradition and joined to it an infiltration of Babylonian learning, in occasional flickerings throughout the Byzantine centuries, and in several of the great Chinese dynasties. But the example unequalled in its opportunities though defective in fulfilment was the early renaissance in which Greek, Persian, and Hindu elements were suddenly synthesised under the Moslem culture centred at Bagdad. The combined scientific, philosophical, poetic, and artistic impulse lasted from the ninth to the fifteenth centuries, including transplantings to Moorish Spain and also to the Mongol empire after the sack of Bagdad, but its most vital inspiration came from the court of the Caliphs in the first two or three centuries of this period.

Astronomy and mathematics predominated in these years, since the Bagdad scientists were primarily lovers of pattern and design in the sense which we have been attributing to the typical artistic temperament, but many aspects of experimental science including medicine were also vigorously pursued.

In assessing the historical contacts between science and art, this Moslem renaissance provides a remarkable microcosm exhibiting the rare interpenetration of the two kinds of attitude to experience: in this case the contact was disastrous. For it seems to have been mainly aesthetic attachment to an outworn kinematics that must be blamed, when we condemn Bagdad for persisting in fantastic elaboration of the Ptolemaic error when the latter might have been superseded. The condemnation of these remarkable geniuses is not that they were poets as well as astronomers (like Omar Khayyám a century or so later) but that they were blinded by the exquisite miniature pattern of a geometry; a combination of perfect circles seemed a noble structure adequate to the dignity of the heavens. It fitted many facts with considerable precision, but the non-circular 'conics' were later found by Europeans to fit the facts better and also to yield a general mechanics. The Moslems were so engrossed in the fascinating complexity of circles rolling upon circles, that the chance of representing everything by a single figure so imperfect as an ellipse escaped notice. The conics remained to them a set of models with no relevance to the material universe.

Among the mathematical writers whom I shall mention, many were also poets or philosophers or both: the nature and quality of their poetry I am not attempting to discuss, but the fact that it accompanied a laborious but sterile science is important today, when interpenetration of science with other preoccupations is alternately urged upon us and despised.

II

The observatories at Bagdad were founded about A.D. 820 and A.D. 980, and showed a sense of organisation beyond that of any Syrian, Greek, or Babylonian predecessors. They were the first institutions of astronomical research to correlate library resources with observing facilities on a large scale. Between A.D. 760 and 1000 they collected, translated, and edited the astronomical knowledge of the entire world, excepting China. From Bagdad after the tenth century it diffused throughout Moslem Africa, Persia, Spain;

and from Spain it played its part in stimulating the beginnings of modern European astronomy. It will be a novel but profitable enterprise to ask what was actually read and written at Bagdad by those first ancestors of any modern observatory staff. The present attempt at answering this question is based on the researches of Sarton, Suter, Wolf, Deslambres, Sédillot, Dreyer, and others too numerous for detailed acknowledgement here.

The historical background to the development of the Bagdad institutes of astronomy was as follows. The city had seen much intercourse between Persian, Syrian, Byzantine, and Hindu astronomers since its foundation in 762 under the Caliph Al Mansur, and about 820 the 7th Caliph Al Mamun organised the 'House of Wisdom' or combined observatory and library. The first achievements of this were a redetermination of the obliquity of the ecliptic as 23° 33′, a comprehensive set of planetary tables, and the measurement of a terrestrial distance to correspond with a degree, from which a value of 20,400 miles was obtained for the earth's circumference. Succeeding Caliphs tolerated astronomers and sometimes encouraged them, but by the middle of the ninth century the more practical patrons were private individuals. A temporary revival of royal astronomical enterprise, under the Buwayid princes from Persia, led to a second Bagdad observatory being founded about 980. These institutions seem to have lasted until the sack of Bagdad by the Mongols in 1258, but their greatest activity ended with the tenth century and thereafter was surpassed in Egypt and Spain. After 1258 the magnificent astronomical library no doubt formed the nucleus of the Mongol library at Maragha in Persia, said to have contained 400,000 stolen books.

III

If we classify the Bagdad writings as (*a*) translations of earlier astronomy and (*b*) manuscripts of contemporary research, the first stage of enquiry is to know what literature was available from which (*a*) could be evolved.

The majority of the astronomical manuscripts in existence when Bagdad was founded (762) were either Greek, or derived from Greek and bearing traces of the outlook of writers in Sanskrit, Syriac, or Persian through whose civilisations the Greek ideas had been transmitted. The Greek who most influenced all later astronomy, himself owing much to the Babylonians, was Hipparchus (second century B.C.), but his work exerted its greatest effect through

the writings of Ptolemy (second century A.D.). There had been various Greek editions of Ptolemy, notably by Pappus and by Theon, but together with the mathematical and physical successors to Euclid, Archimedes, Apollonius, Menelaus, and Diophantus these required diffusing beyond their original repository in the school of Alexandria. A valuable channel for this diffusion was opened by Proclus (*c.* 410-85); he carried Ptolemaic traditions to Byzantium and Athens and taught Ammonius, whose brother Heliodorus was an astronomical observer between 498 and 509 and probable author of an introduction to Ptolemy's greatest work, the Syntaxis or 'Almagest'. Three other pupils of Proclus and Ammonius helped to link Greek with Arab astronomical literature, namely Philoponus whose treatise on instruments is now available in Dr. Gunther's 'Astrolabes', and Damascius and Simplicius who dominated the academy at Athens until Justinian closed it in 529. From then until 533 these two were exiled in Persia; they were hospitably entertained at the court of King Nushirwan, and if only we knew whom they met there and with whom they discussed their own commentaries on the older Greek scientists, we could complete the connection between ancient astronomy and Bagdad, for some of the earliest of the Caliph's astronomers were Persians.

The Syrian version of Greek astronomy has been even less explored, but one striking example is Bishop Severus Sebokht's treatise on the astrolabe, about 662, based exclusively on Greek sources, and now in Dr. Gunther's book. Sebokht also wrote on the zodiac and on eclipses, but his greatest importance is his mention of the Hindu numerals, since the scientific achievements of Bagdad were only made possible by the fusion of Greek ideas with the less clumsy Sanskrit numerical notation. Apart from that notation, Hindu astronomy is undoubtedly of Greek origin, since even the Sanskrit constellation names are Greek words in disguise, as expounded in the Siddhantas and especially in the writings of Aryabhata (*c.* 500), Varahamihira (*c.* 550) and Brahmagupta (*c.* 630).

The more important of the Persian and Syrian channels supplying Greek astronomical manuscripts to Bagdad have been correlated in Dr. O'Leary's 'Arabic Thought'; they include, in addition to those I have mentioned, the pagan Harranian settlements where classical tradition survived longer than anywhere else in the East, and the scientific schools at Jundishapur and elsewhere frequented by Nestorian refugees. The final state of Bagdad science reached,

just before the observatory was founded and before Ptolemy's works were read there, can be very clearly seen in Dr. Mingana's recent edition of the 'Book of Treasures' of Job of Edessa, while the older pre-Hindu Greek and Egyptian notations of the Byzantine world appear in the Akhmim mathematical papyrus and in the papyrus recently edited by Michigan observatory.

IV

With the literature of Greek astronomy scattered in the manner I have described, it is clear that the first task of organised science in Bagdad was to translate into Arabic from these Byzantine, Syriac, Persian, and Sanskrit derived manuscripts. I shall in this section regard Bagdad observatory as a bureau of translators, as it mainly was in its earlier years; its own later researches only become intelligible against such a background.

The first translations were probably made under the Ummayid Caliphs of Damascus before Bagdad was founded, but no details survive. In 767 or 773 occurred a significant event in the scientific life of the new city, the arrival at Al Mansur's court of a Hindu with a compendium of his people's astronomy, probably in the form given to the Siddhantas by Brahmagupta 150 years before. The first Bagdad writer known to have profited by this was Yaqub ibn Tariq, a Persian, in his memoirs on the sphere, on trigonometry, on Hindu astronomical tables, and on the calendar, all before 778. Actual translation from the Siddhantas into Arabic seems to be first due to the younger Al Fazari about 773. Ibn Naubakht, Persian librarian to Harun al Rashid the 5th Caliph, is perhaps the first astronomical translator into Arabic from Persian, thus opening another of the channels which I described as carrying Greek ideas. Direct translation from Greek science seems to have begun in Harun's reign (786–809) with the Euclid of Al Hajaj; the latter also translated Ptolemy's Almagest in 827–8 under Al Mamun the 7th Caliph, who founded the 'House of Wisdom' about then. This was not the first Arabic edition, but the earliest reliable one, and the translator probably utilised a Syriac version made by Sergius of Resaina in the sixth century. About this time Al Batriq translated Ptolemy's 'Tetrabiblos', and before the death of Mamun in 833 a number of other translations were added, notably from Persian by Al Farrukhan and from Greek by Al Kindi, together with commentaries by Al Abbas on Euclid and by Al Farghani and Al Farrukhan on Ptolemy. But by the middle of

the ninth century the influence of the Caliphs had weakened and left the encouragement of science to private individuals; the most famous of these were the three sons of Musa, who devoted their wealth to acquiring Greek manuscripts and employing a staff of translators, much as Mamun had earlier sent his missions to obtain Greek books from Leon the emperor of Byzantium.

The time of the Musa brothers was the greatest age of astronomical translators in Bagdad. The first to mention is Hunain ibn Ishaq, 809–77, who spent his early years at Jundishapur where all the older scientific cultures met, and then was in Bagdad until his death. His method was to translate from Greek to Syriac and then to supervise pupil translators from Syriac into Arabic. His son Ishaq ibn Hunain translated astronomy and mathematics from Aristotle, Euclid, Ptolemy, Menelaus, Archimedes, Autolycus and Hypsicles. Thabit ibn Qurra, 826–901, was the leader of this school and employed the same method of a Syriac intermediary between Greek and Arab astronomy. He revised Ishaq's work and himself translated from Apollonius, Archimedes, Euclid, Theodosius, Ptolemy, and Eutocius. Other translators for the Musa family were Al Himsi, responsible for several books of Apollonius, and Yusuf al Khuri. The latter seems responsible for Archimedes' lost work on triangles, revised later by a son of Thabit in the tenth century. Qusta ibn Luqa, a Greek Christian in Bagdad, translated from Diophantus, Theodosius, Autolycus, Hypsicles, Aristarchus, and Heron; it is seen that by this time the minor authors were being added and the scientific outlook broadened.

In addition to these translations, the observatory at Bagdad had also been accumulating commentaries. Ibn Sinan, 908–46, grandson of Thabit, wrote on the Almagest and on books upon conics. Al Farabi wrote on Euclid. Al Mahani wrote on Archimedes' famous 'Sphere and cylinder' and on Euclid. Al Nairizi's commentaries on Ptolemy and Euclid survived into Europe through a Latin version made by Gerard of Cremona. Ibn Luqa wrote commentaries on Euclid in addition to his translations. This part of the observatory routine was not allowed to stagnate even when research had largely replaced translation; *e.g.* in the later years of Bagdad we find Abul Fath, the Persian, writing commentaries on the Conics of Apollonius, improving the editions of Books 1-4 previously due to Al Himsi and of Books 5-7 previously due to Thabit. Even the most original observers and mathematical discoverers, such as Al Battani and Abul Wafa, added to the standard editions of the older astronomy.

V

It was against this background of painfully inherited astronomical knowledge that new developments in observation and in the mathematical treatment of astronomical data were being made in Bagdad, as follows.

At the very beginning in 762, the Persian Al Naubakht, father of the translator whom I have mentioned, worked with the Jew Mashallah as astronomers in addition to being surveyors for the foundation of the new city. The only writing now ascribed to the former is the astrological 'Kitab al Ahkam', but a treatise by Mashallah is the earliest Bagdad text-book to be used later in Europe; it was translated into Latin by Gerard of Cremona in the twelfth century under the title 'De scientia motus orbis' and was printed in 1504. Another father of a translator mentioned above, Al Fazari, is said to have been the first constructor of astronomical instruments in Bagdad, before the observatory was organised, and wrote books on the astrolabe, on armillary spheres, and the calendar.

The greatest of Mamun's reign was probably Al Khwarizmi, who died about 850, one of the founders of algebra; he constructed the first Moslem astronomical tables, including primitive uses of sine and tangent, and also took part in the Caliph's degree measurement. His tables and a treatise on arithmetic reached Europe in a twelfth-century Latin version. His great contemporary Al Farghani, who worked on distances and diameters of planets and the size of the earth, wrote an 'Elements of astronomy' which also had a great European vogue in later centuries. Al Hasib, or 'Habash the computer', observed 825–35 and was author of three sets of astronomical tables, one in the Hindu and the others in the Moslem manner. He is the first known to have determined time by altitudes, in an eclipse of 829, a method rediscovered in Europe 600 years later. Other contributors in Mamun's reign were Mansur the Persian together with sons of Habash the Computer and of this Mansur, and Sanad ibn Ali the author of tables and of a work on specific gravity; at this stage of Bagdad observatory development it is significant that the last three mentioned were all designers of instruments, as technique was not yet stabilised. Another case of the family inheritance which characterised these astronomers was Al Marwarrudhi, who began by solar observation at Damascus and Bagdad and had an astronomer son and a grandson who wrote treatises on instruments and tables. Such links with older cities were not confined to Damascus, since another contemporary, Al

Nahawandi, was associated with Jundishapur. The last great worker of Mamun's age is Al Kindi, who in addition to his translations wrote an important work on geometrical and physiological optics, which had great influence in later Europe when translated by Gerard of Cremona under the title 'De aspectibus'.

After Mamun's time research continued at his observatory. The brothers Musa, whom I described as patrons of the succeeding 'age of translators', were also actual observers, credited with the first remeasurement of the maximum latitude of the Moon, and were authors of 'The book of the balance' and 'The book of measuring spheres'. We find also Al Mahani writing a series of lunar and solar eclipse observations and planetary conjunctions, 853–66, Ahmad ibn Yusuf writing a geometry which influenced the European founders of mechanics through the later diffusion from Bagdad, although he actually worked in Egypt, and Al Nairizi writing a treatise on atmospheric phenomena and also the best extant treatise on the astrolabe. Even the great translators, Thabit, Hunain, and Ibn Luqa, contributed original work also, the first-named having a bad reputation in modern days for his erroneous theory of 'Trepidation of the equinoxes'; Hunain wrote on tides, meteors, and the rainbow; Ibn Luqa's work 'De sphaera solida' reappears in the thirteenth century in the Spanish encyclopedia of astronomy 'Libros del Saber'. Al Sarakhsi was a pupil of Al Kindi, Mamun's translator, but was tutor to one of the Caliphs and was executed. The titles of some astronomical MSS. at this time are picturesque; Ibn al Adami's tables were completed after his death in 920 as 'The arrangement of the pearl necklace', while astronomical tables in Persian by Ibn Amajur were called 'The pure', 'The wonderful'; treatises by Al Balkhi had the intriguing titles 'The excellence of mathematics' and 'The figures of the climates'.

The greatest of this age was probably Al Battani, *c.* 850–929, who seems to have worked mainly at Raqqa on the Euphrates, but is also reported at Antioch, Damascus, and Bagdad. He found that the longitude of the Sun's apogee had increased 16° 47′ since Ptolemy's time; this has been taken as implying his discovery of the motion of the solar apsides. He reports precession as 54″·5 and the inclination of the ecliptic as 23° 35′ when 23° 34′ 54″ would be correct for his date. His chief contributions to the Bagdad library were probably the 'De scientia stellarum' and 'De numeris stellarum et motibus' which we possess in twelfth-century Latin form, and which together with the works of Al Farghani of Bagdad were among the greatest influences on the European renaissance.

By the end of Al Battani's generation the encouragement of astronomy, left since Mamun's reign mainly in the hands of individuals such as the Musa, had dwindled; I mentioned in the first paragraphs the revival under the Persian prince Sharaf al Dawla, who built a new observatory in his palace gardens at Bagdad.

The greatest of the corps of astronomers associated with this new observatory was Abul Wafa, 940–98. He wrote much new geometry, but above all he is the greatest trigonometrician of Bagdad. We possess later adaptations of his tables, which included tangents, secants, and cosecants, some of them correct to many places of decimals. He discovered many of the equations inter-connecting the different trigonometrical functions. He wrote an arithmetic, and his 'Kitab al Kamil' or 'Complete book' became a standard simplification of the Almagest.

Another writer under these new Persian governors of Bagdad was Ibn al Alam, whose astronomical tables were used for the succeeding two centuries. Al Sufi, 903–86, was a friend and teacher of the governing prince, and author of a 'Book of fixed stars', one of the chief works of Bagdad to influence subsequent science. The principal instrument designer for the new observatory was probably Al Saghani, author of writings on the trisection of angles, while the director seems to have been Al Kuhi, who specialised in Archimedean and Apollonian problems, *e.g.*, concerning equations of higher than second degree.

A feature of this last age of Bagdad enterprise was the production of encyclopedic works; the 'Book of Creation' of Ibn Tahir synthesises the whole body of Arab, Persian, and Jewish research, and we know also of the following three compendia. (i) The 51 tracts on the classification of the sciences and their relation to other aspects of culture, edited by the 'Brethren of Sincerity', a secret society established about 983 at Basra. (ii) The 'Keys of the sciences', of about 976. (iii) The 'Fihrist' or biographical index of all Moslem astronomers and writers, compiled about 988 by one known as the 'Bookseller of Bagdad'. These works represent the stage reached after two and a half centuries at Bagdad had established a systematic use of Greek astronomy together with a large mass of original observations, tables, theories, and new mathematics.

Two last names stand out before the decline of Bagdad astronomy and mathematics, and indicate that the problem of choosing a notation still survived; Al Karkhi, who died about 1020, despised and avoided the Hindu numerals, while his contemporary Al Nasawi expounded them.

After this the great Moslem scientists are found in other centres than Bagdad. For instance, Al Zarkali and Al Betrugi worked in Spain, and Al Haitham and Ibn Yunus in Africa; and then came the great Mongol and Persian observatories of the thirteenth and fifteenth centuries, when Europe too was beginning to develop at last an astronomy of its own, but Bagdad itself was no longer the world's centre of astronomical research.

VI

I add a brief critical note on the methods by which (*a*) inclination of the ecliptic, (*b*) precession, (*c*) longitude of the Sun's apogee, were measured and represented in the MSS. which I have been discussing.

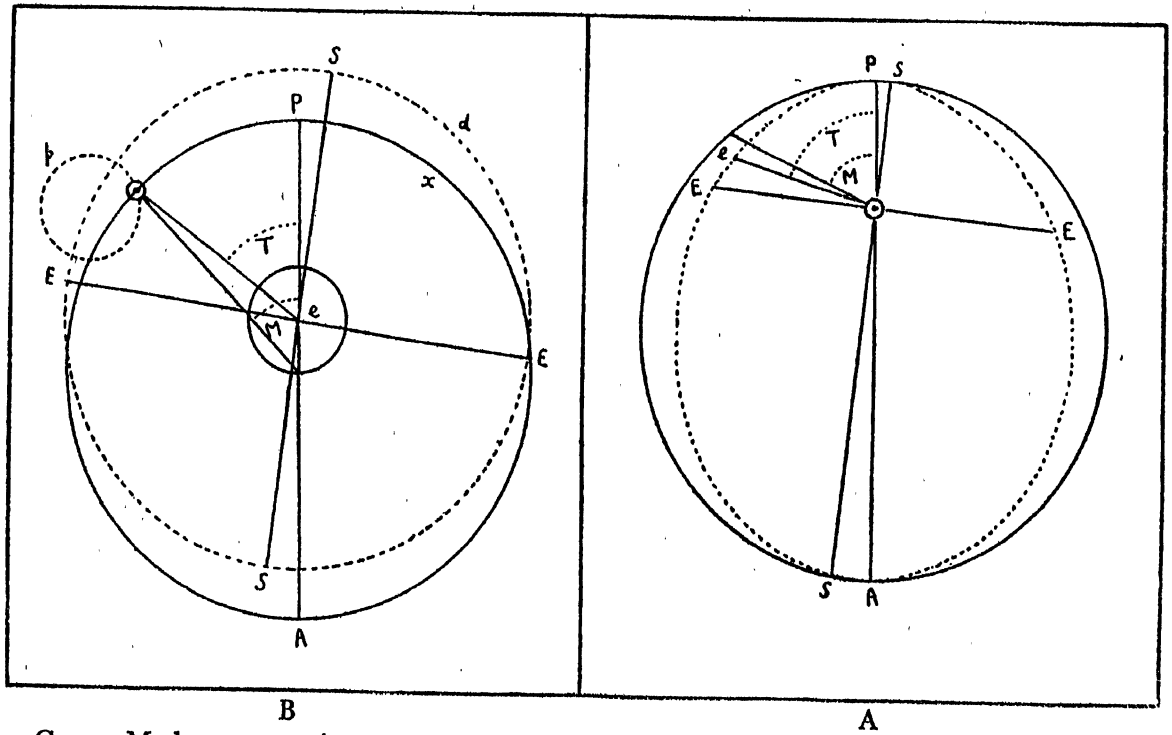
(*a*) In Mamun's Caliphate, inclination of the ecliptic was obtained from a pillar or Gnomon surrounded by concentric circles, the vertical and horizontal being secured by plumb-line and water level. Contact of the pillar's shadow with one of the circles at two points before and after noon gave an angle whose bisection determined the meridian. Zenith distances of the Sun were obtained from the radii of the circles and the height of the pillar, in one case reported as 180 feet. To obtain the inclination of the ecliptic and geographical latitude, the maximum and minimum of solar meridian zenith distances were derived by plotting around the time of solstices. It is difficult to credit the shadow method with giving 23° 35′ within a few seconds of the correct value, and it is likely that early in the tenth century the more refined method was developed, of which we have details in Al Khujandi's 'Inclination and latitude' of 994 A.D. A later version of this MS. has been translated into French, and describes the erection, levelling, and orientation of the large sextants and quadrants which came into use under Sharaf al Dawla. A solar image was formed on the circumference by illumination of a pinhole aperture at the centre, and an artificial solar disc marked with perpendicular axes was fitted to the image to determine the exact coincidence between centre of disc and scale division. Very large instruments were built at this time, the sextant of Al Khujandi having a radius of 60 feet, with each minute divided into ten parts. He obtained 23° 32′ 21″, an error of 2′, which suggests that the greater accuracy of Al Battani, Abul Wafa and others was fortuitous since their smaller instruments could not have been so subdivided in scale.

(*b*) Precession measurements depended on the accuracy with

which the difference between Tropical year and Sidereal year could be observed. About 20 minutes' difference corresponds to a precession of 50″, and in the tenth century at Bagdad this was recorded with precision, but with a reliability difficult to assess as we know little of the methods by which the heliacal risings were utilised to obtain the Sidereal year. One of the most tragic blunders of the Moslems was a belief, based on the varied reported values, that precession had a periodic fluctuation.

(*c*) The artificial solar disc on Al Khujandi's giant sextant would afford a means, with the accuracy of his scale, of tracing the solar apogee by the changing solar diameter, but I have not found any writer of that age to suggest this. It is more likely that 'longitude of solar apogee' was simply an angle on a diagram, whose value had to be adjusted (together with a numerical value of eccentricity) to account for the observed unequal intervals between solstices and equinoxes. The accompanying figure indicates the way in which this and associated quantities on a typical Bagdad diagram would correspond to those of a modern heliocentric ellipse. There are three ways of representing the apparent relation of Sun to Earth, and Dreyer in his 'Planetary Systems' remarks on their formal equivalence to an accuracy of one minute of arc; (i) the modern ellipse, fig. A, (ii) the Graeco-Moslem geocentric system in which the Sun or planet moves in a small 'epicycle' (*p*) round the circumference of a 'deferent' (*d*) at whose centre is the observer. This system is shown dotted in fig. B. (iii) The alternative Graeco-Moslem geocentric system in which the Sun or planet moves in an 'eccentric' (*x*) whose centre is displaced from the observer. This system is shown in full line in fig. B. The Sun ⊙, earth *e*, apogee A, perigee P, equinoxes EE, solstices SS, and mean and true anomalies M, T, are lettered similarly in the ancient and modern diagrams. The angle between EE and AP diminishes by about 61″ per annum, due to the 50″ precession and 11″ motion of apogee. So far as the Moslems were concerned, AP could be *defined* as the line joining the centres of *d* and *x* since they knew nothing of elliptic orbits, and by 'fitting' the inequality of the seasons they determined the longitude of this line in the tenth century; but in comparing with Greek data and noting that a change had taken place they used an inaccurate precession and also took Ptolemy's epoch as his own whereas it was probably that of Hipparchus, so that their discovery of the motion of the apsides was only qualitative.

By the kindness of the late Dr. Mingana I was allowed to select a hitherto unpublished example from his unrivalled collection of



B

Graeco-Moslem geocentric systems (circular).
---------- epicyclic method.
———————— eccentric method.

A

Modern heliocentric system (elliptic).

to demand careful and detailed investigation. The tale, when complete, may turn out to exemplify rather than to contradict the conservatism which blighted the fruits of all Chinese scientific diligence.

Since Dreyer's paper, little but photographs and abstracts of the work of Wylie and of Yule has been published; meanwhile the two instruments have undergone sundry transplantations, Chatley in 1938 recording them in Nanking. I suggest two reasons for re-examining on a new basis the disturbing implication of these Mongol instruments, and discussing whether for centuries an isolated Oriental technique was really in advance of our Western astronomical ancestors. Firstly, the study of early apparatus is nowadays capable of not only a historical but an anthropological stage; it has become essential to follow up the reconstruction of old knowledge by asking whence that knowledge evolved or through what migrations of culture it had been transmitted. In particular it must now be recognised that many local astronomical discoveries originate spontaneously anywhere, such as the recording of lunar and solar cycles, but that others such as arbitrary technical devices can only be regarded as descending from earlier practices current elsewhere. The two Mongol equatorials offer uniquely profitable material for developing such a stage in the study of the scientific past. My second reason for this new investigation is the vast body of facts concerning the migration of astronomical and mathematical knowledge over the medieval Moslem world: many of these facts have been collected subsequent to the work of Dreyer, Wylie, and Yule. This migration played an indispensable part in the origins of European astronomy, and the real status of Chinese science will only be discovered if it becomes possible to assess the corresponding part played by Moslem astronomy in the less susceptible Far East.

II

The Yule-Wylie Identification of the Instruments

The two surviving equatorials may be very briefly described, and associated with the equipment of a particular observatory, as follows. The first, (*a*) is a skeleton globe about six feet in diameter with eighteen foot base and observing platform, comprising a set of concentric bronze circles of similar size but varying orientation, with diametral tube for sighting a star whose angular position is to

be read by means of scales on the circles. In general purpose it is not unlike the armillary spheres or spherical astrolabes which were the chief observing equipment of the Greeks, the Moslems, and the pre-telescopic Europeans: in technical details it differs from all other known examples, by features which I compare in a later section. The second, (*b*) is a compound of three circles not concentric, the two larger of which lie in planes respectively parallel and perpendicular to the polar axis. The upper and lower ends of the latter are massively supported. Diameter and base are of the same order of magnitude as in the other instrument. Mountings of each survive, heavily ornamented in the dragon fashion, together with accessories where they are of bronze, but certain fine wires for sighting, mentioned in early sources, have perished. The Royal Astronomical Society's library now possesses a number of photographs from which it appears that in the second instrument the Declination and Right Ascension were obtained in exactly the manner of the 'English mounted' equatorial telescopes of the nineteenth and twentieth centuries, and three hundred years before Tycho Brahe made possible a similar technique in Europe. By combining (*a*) and (*b*) many of the standard measurements of a modern observatory are available, definition of image lacking only lenses.

It is important to enquire with what other apparatus these contributed to the working resources of a standard observatory in 1279. There is a valuable hint from the clue given by Yule to Wylie, as follows.

Wylie's account translates the detailed description of (*b*) from the Yuen-she or chronicle written in the fourteenth century for the early Ming dynasty, while Yule's account utilises the statements of Ricci the Jesuit astronomer. In 1599 Ricci saw at Nanking two instruments precisely similar to these, accompanied by two others of which no counterpart exists now; the latter were (*c*) a globe about six feet in diameter with meridians and parallels, (*d*) a gnomon about twelve feet high with water levels in a marble base and graduated on slab and style for reading solstitial and equinoctial shadow lines. From the recent investigations of Henri Bernard, it seems that Ricci failed to realise that the star groupings associated with these instruments were equatorial and not just the zodiac of Moslem-European tradition. A puzzle arose from Ricci's report that these Nanking instruments had a polar elevation of 36°, as Nanking is at latitude 32° and Peking at 40°, but the scheme into which all these equatorials fit is clarified on Yule's theory. Yule

found that in 1233 Ye-Lu-Chu-Tsai built two colleges, one at Yen-king (Peking) and the other at Ping-yeng (lat. 36°). It appears that, about 1279, each was equipped with this ensemble of four instruments, of which Ricci saw the set which in the scientific decadence of the Ming had been removed to Nanking, while the present survivors are all that remain of the duplicate set. This allows the supplementing of the survivors by Ricci's description, since his report and the Yuen-she agree when they speak of the corresponding instruments.

The problem of local invention or transmitted design of these works of art and science can now be attempted, beginning with an enquiry as to what contacts with Western astronomy were open to the designers, or to Chinese of earlier date whose records might be locally available.

III

Contemporary Contact with Western Astronomy

The instruments of 1279 were built under the direction of Kuo-Shou-Ching (1231-1316), a hydraulic engineer and trigonometrician, who was commissioned by the Khan Kubilai in 1276 to reorganise the astronomical and calendar service of the Mongol empire. At that epoch, maintenance of a single authority from the Pacific across Asia almost into Europe enabled the Khans to draw upon the entire heritage of the world's previous science for all technical requirements. For instance Arab engineers were in the Mongol service in 1270, and Central Asiatic craftsmen were widely used. In state-organised science Kubilail maintained two astronomical boards of experts, one Moslem and one Chinese, with independent instruments: I refer later to the peculiar ignoring of the former in official time-keeping, but so far as nominal constitution and membership went, foreign contributors were encouraged. It is even recorded that a prominent member of the state mathematical council was a Byzantine, and within the same generation a Russian and an Italian are mentioned as being at court.

A significant individual instance of foreign knowledge accessible to the associates of Kuo is Cha-Ma-Li-Ting. This name is accepted as a Chinese version of Jamal-al-din, a Persian who in 1267 submitted to the Khan a Moslem calendar system to cover 10,000 years, together with seven Persian astronomical instruments including an armillary sphere. We have no evidence as to any particular observatory at which Jamal was trained, but this is a less serious

deficiency in view of the widespread pooling of West Asiatic science in that generation; during the preceding forty years all the Moslem scientific institutions from Samarkand to Bagdad were ransacked in the overrunning of Asia by the Mongol conquest, and their culture sifted and integrated at Maragha. The 400,000 books ascribed to the new Maragha observatory, built in 1259, represent this enforced centralisation of Arab-Persian astronomy. Of the staff at Maragha, Nasir-al-din-al-Tusi the director edited the most essential Greek mathematicians and astronomers and also researched in planetary theory and trigonometry, Al-Urdi the instrument designer had built apparatus in Damascus, Al-Maghribi had Syrian and possibly Spanish experience, Al-Shirazi had worked in Iraq and Egypt, Al-Futi the observatory's librarian had been captured at the sack of Bagdad itself, and Abul-Faraj the lecturer had worked at Antioch, Bagdad, Mosul, and Tabriz. Although communication between eastern and western territories of the Mongol empire was inevitably slow, this range of the workers at Maragha indicates the contemporary interdependence of nearly every scientific centre of importance among those descended from the Greek. It conveys something of the universality of experience opened to the central government at Peking when admitting into astronomical society such western visitors as Jamal.

There are other names which also emerge among the uncertainties in scientific history of that age. In 1263 Isa the Mongol is reported as director of the astronomical council at Peking; as he was a Nestorian his intellectual background was at least as Western as that of Jamal, and indeed he is traced journeying in Persia, but not until 1284 after the building of the two instruments of Kuo. Another individual of possible importance to the designs of Kuo is Chau-Ju-Kua, who about 1266 is said to have brought to China a personal acquaintance with Hindu astronomy. The annotations to the Western Asiatic journeyings of Chau-Ju-Kua (Hirth and Rockhill, 1911) make it clear that Bagdad of the mid-thirteenth century, with its unrivalled repositories of Graeco-Moslem astronomy, was not unknown to the intellectual Chinese at the transition from Sung to Mongol dynasties. It was the culture of this transition which formed the educational background of Kuo when he designed the instruments which I am discussing.

Besides such importations from the West there was a little scientific export from China: Al-Maghribi, writing in 1264 a treatise on Chinese astronomy, had a Chinese colleague with him at Maragha observatory. Chinese scholars were widely used by the

Mongols as envoys, such as Chang-Ti sent by Mangu Khan to Bagdad in 1259. It is not to be believed that the metropolitan science at Peking, so precisely organised by imperial patronage, can have remained less aware of foreign ideas than were the outlying dependencies of the same government. The years in which Kuo designed his instruments were a time of closer acquaintance with Western astronomy than perhaps any until the present century. I shall indicate later the extent to which intellectual conservatism inhibited the full use of this acquaintance.

IV

Contact with earlier Western Astronomy

In designing his instruments at Peking, Kuo was not dependent solely upon those of the same generation whom we have shown to be associated with Western science. Maragha observatory was only twenty years older than the new institution ordered by Kubilai for Peking, and although Jamal and Isa were probably familiar with its innovations we can only regard the latter as additions to what had been collected from the many conquered Moslem centres. It is desirable to enquire at what earlier date the Chinese were likely to have been introduced to the predecessors of Maragha astronomy, and to watch for any changes in Chinese designs accompanying such introduction. That the pre-Maragha astronomical culture was already known to the masters of Kuo in the generation before he worked, may be suggested as follows. It is instructive to take the list of observatories at which standard determinations of the ecliptic angle were made by the Moslems (Schirmer, 1926) and to compare with this list the itineraries of two astronomically minded Chinese travellers to the West and back some time before the commissioning of Kuo. Ye-Lu-Chu-Tsai (1190–1243) the mathematician who finally became chief general confidant to the Khans, and who founded the two colleges mentioned, accompanied Genghis to Western Asia, 1219–24 (Bretschneider, vol. I). Following his Persian travels he formulated his own theory for calendar reform. During the journey the troops are said to have collected from Persian, Arab, and Syrian spoils the instruments and books in which he was interested. His influence at the Mongol court in later life was unprecedented, and his presence alone was sufficient to ensure an open mind towards Western science. The other relevant individual is Chang-Chun. This monk was sent across

Asia by order of Genghis in 1220 and returned after several years to Peking, where he was regarded as a supreme intellectual and spiritual adviser. There may be seen in Waley's annotated translation (1931) the notes made by the secretary of Chang-Chun during the journey. Not only did he carry out astronomical observations en route but utilised opportunities of acquaintance with local science. Thus while halted at Samarkand he correlated with the local astronomers their time measurements and degrees of partiality for the eclipse of 23rd May 1221 and formulated the detailed physics underlying the measurements.

I have assembled these facts to indicate that the designers of the instruments of 1279 were extremely unlikely to be ignorant of the state reached by Moslem astronomy in their own and the immediately preceding generations. But prior to the Mongol unification of China and Western Asia about 1220, Chinese astronomers had been far more isolated. For estimating the earlier foreign influences relevant to the instruments of 1279 it is enough to mention very briefly that the Sung dynasty (960 until the Mongol conquest) was a period in which a minimum of outside contact was allowed, until in its last days there occurred the interchanges which I have been discussing. In the T'ang dynasty (618–906) incidental scientific contacts may have occurred from time to time through Moslem and Byzantine trade, and there are glimpses such as are afforded by Sir Aurel Stein's find of 15,000 books stored at a centre of Chinese culture in eastern Turkestan. These books include Sanskrit, Hebrew, and Persian works dating from the ninth and tenth centuries at an age when scientific writing in these languages was important. There are also the famous Buddhist journeys in the seventh century bringing intellectual intercourse to China from India and Persia; it is certain that Chinese mathematicians knew of the Hindu numerals in the sixth or seventh century, but also that these had little effect compared with the far greater impulse which they gave to the Moslem astronomical renaissance of ninth-century Bagdad. In the fifth and sixth centuries Chinese were in Persia, but we can at present only speculate as to whether they met the six Greek scientists exiled from Athens and resident at the Persian court during A.D. 529–33, and also whether they utilised the great repository of Greek science at Jundishapur. But there is no doubt at all that in the Alexandrian era there was considerable contact between Chinese of the Han dynasty (206 B.C.–A.D. 220) and Greek culture in Bactria; for instance traffic along the silk route was not limited to material merchandise. A case has also

been made out for Chinese acquaintance with Babylonian astronomy before the time when the latter was stimulating the origin of Greek astronomy. Bezold (1920) assessed some of the available evidence connecting Chinese Han astronomers with Babylon of the second century B.C., with possible earlier connections between the Chou dynasty and the Babylonian scientific culture of the Assyrian library of Assurbanipal; it seems clear that by 523 B.C. at the latest the Chinese possessed some acquaintance with Babylonian stellar observations, and Bezold even contemplated intercourse in the second millennium B.C. The Chinese who built equatorials which were already old when reported by Szu-Ma-Tsien about 100 B.C. may have learnt as directly as the Greeks themselves from the great Babylonian pioneers of astronomy, Kidinnu and Naburiannu, whose remarkable work has now become known through the studies of the late Dr. Fotheringham.

V

Observatories capable of Influencing the Designers of 1279

From the foregoing assessment of foreign contacts open to the assistants and predecessors of Kuo, a reasonable distinction between technique relevant and irrelevant to the instruments of 1279 can now be made. Although it seems likely that the earlier Chinese astronomers were acquainted with Babylonian ideas, too little is known about the equipment of either to be able to trace copies. But since certain obvious modes of recording angular position by means of great circles of a sphere will evolve inevitably in the most isolated of scientific communities, it is not so serious a loss that no data survive concerning the most primitive instruments. It is only when the choice of coordinates and the graduating of scales becomes characteristic of particular schools that similarity between widely separated local techniques can imply transmission of design. Accordingly it is after Babylonian astrology had stimulated the genuine scientific impulses of the Greeks, and through Hipparchus a systematic observational method had been developed at Alexandria, that the details become available which are relevant to the Chinese problem of 1279.

It is also, significantly, this late Greek age which reached a maximum intercourse with the Chinese.

The Alexandrian equipment, as it was in A.D. 140, may be summarised sufficiently as follows from Gunther. (1) Circle in

equatorial plane; (2) vertical circle in meridian, the two constituting the so-called 'equinoctial and solstitial armillae' for observing coincidences with shadows; (3) mural quadrant; (4) Ptolemaic rule or jointed oblique arm on vertical hinge; (5) astrolabe for celestial latitude and longitude, i.e. using an ecliptic coordinate system; (6) armillary sphere, which according to Tannery had nine circles and hence was probably capable of equatorial measurements although these were not in use until much later; (7) gnomon in hemisphere such as was associated with Aristarchus of Samos.

The decay of observational astronomy, which persisted until the revival at Bagdad in the ninth century, means that occasional post-Han acquaintance with Western science can have provided the Eastern designers with nothing beyond this Alexandrian equipment for the next 600 years. If Chinese envoys at the Persian court did carry home any products of meetings with Greek mathematicians in A.D. 530, accounts of Alexandrian methods such as the treatise of Theon represent the most that they can have acquired. The same can be said of Buddhist infiltrations culminating in the seventh century, whose main scientific function was the transmission of the Hindu numeral system with little observational background.

It is remarkable that the greatest of all pre-modern eras of research, the Moslem period whose initial stages at Bagdad alone are represented by nearly a hundred astronomical authors, can have influenced Chinese science so little prior to the thirteenth century. Without those earlier Moslems the origins of European science would have been crippled, but the isolationist policies of the Sung dynasty left the Chinese much more dependent upon their own and other pre-Moslem tradition. The intensely active observatories of Damascus, Antioch, Bagdad, Rey, Cairo, Morocco, and in Moorish Spain Cordova, Seville, Toledo, only begin to become significant for Chinese astronomy shortly before the final coordination of their products into the body of learning centred at Maragha: that last stage I have shown to be accessible enough to Peking.

This peculiar feature of Oriental scientific history simplifies greatly the possible antecedents of the Peking instruments: only the equipment from Maragha is required, as representing the final expression of all foreign technique which reached Chinese astronomers just at its culmination.

Such estimate of the instrumental resources at Maragha is now

available through Seemann's translation of the MS. attributed to Al-Urdi himself, the chief designer of that observatory, as follows. (*a*) Eleven-foot mural quadrant; (*b*) armillary sphere of four great circles and a small circle of latitude carrying an alidade or line for sighting; (*c*) and (*d*) solstitial and equinoctial rings similar to (1) and (2) of Alexandria, but of 2½-metre diameter compared with the Greek 16-inch; (*e*) Hipparchus' apparatus for obtaining solar and lunar image diameters; (*f*) double quadrant; (*g*) Ptolemaic rule developed from (4) of the Greeks but very much larger with a limb of 17½ feet; (*h*) and (*j*) scales for instrumental determination of trigonometrical functions.

It will be noticed at once that the principal developments since the Alexandrian age are, firstly, the graphical and instrumental methods for solving trigonometrical problems, required by the great Moslem expansion of that subject, and, secondly, the much increased accuracy through size of apparatus. At Maragha was probably attained the optimum combination of size with stability, a maximum in sheer size alone having been passed when Al-Khujandi built a sixty-foot sextant at Rey about A.D. 994. Thereafter the temptation to rely on size alone in primitive instruments only reappears in the eighteenth century in India (Jaipur), where there still exist gigantic observatory constructions: these were inspired by the pre-telescopic Moslems of fifteenth-century Samarkand, but were built centuries too late to compete with the science of post-Renaissance Europe.

I proceed to compare the Peking designs with the Greek and Persian equipments, which I have shown to be the only alien predecessors whose influence is likely to be relevant to the question of their origin.

VI

Contrasts between the Peking Instrumental Designs and those of Alexandria and Maragha

(1) As regards ensemble, the evidence which I have utilised from Ricci and from the Yuen-she through Wylie and Yule is to be compared with Seemann's translation of Al-Urdi and the accounts of Alexandria. The Mongol instruments exhibit a simplicity which is not primitive, but implies a practised skill in economy of effort, and in this sense compares favourably with the Graeco-Moslem tendency to rely on separate instruments for each single coordinate

to be measured: neither Alexandria nor Maragha exhibit any device so complete and effective and yet simple as the instrument of Kuo which I denoted as (*b*). Actually our present-day equatorial mounting has made no further essential advance. Where the Greeks and Moslems had the greatest advantage was in matters dependent upon their respective supremacies in theoretical reasoning, and therefore in apparatus designed to facilitate that particular aspect of their genius. For instance the principal superiority of Moslem (not Greek) instruments lay in their adaptability to direct solution of geometrical and trigonometrical problems, the Chinese never having reached the precision or the complexity of analysis requiring that part of the Arab-Persian equipment which could be called 'mathematical machinery'.

It is significant in this respect to notice the distinction introduced by the Erlangen school of scientific historians. Other writers had used indiscriminately the terms 'spherical astrolabe' and 'armillary sphere', but Seemann's monograph (1925) on the former insists that this instrument proper did not exist among the Greeks and could arise only from the Moslem genius in trigonometry. The instruments more suitably classed as armillary spheres, and discussed exhaustively in Nolte's monograph (1922) from the same school, served observational purposes rather than those of projective geometry, and alone appear in Greek and Chinese as well as Moslem science. The Greek rather than Moslem affinities of the Peking instruments are again emphasised when Chatley reports that the Chinese had always neglected the problem-solving facilities of the fully developed astrolabe.

(2) It was from the first realised by investigators of the 1279 instruments, that their division of the circle into 365¼ degrees each of 100 minutes distinguished them from all Graeco-Moslem-European notation, which seems to have been always unanimous in retaining the 360-60-60 angular system which is probably Babylonian in origin.

(3) In minor technical details also, the Mongol instruments were unique. The alidade, which seems to have been a hollow cylinder with cross-wires now perished, was a device more akin to modern telescopic usage than the sighting devices of the Moslem astronomers; these usually consisted of two parallel but laterally displaced radials, often with external sights. Sighting across the circles of the Peking instruments was also facilitated by the bronze hoops being doubled with an observing space between, allowing strength of structure with accuracy of setting.

(4) Ricci mistook several features of Chinese astronomy by failing to realise its universal reliance upon equatorial coordinates in place of the ecliptic. The latter had served the entire Graeco-Moslem world and all Europe, until Tycho Brahe on building instruments of both types had realised for all future astronomy the great advantage of the equatorial. Since Bernard's discussion now corrects Ricci in this, the Chinese discovery can stand as a striking feature of their isolated development of their own genius so many centuries in advance of European practice.

(5) The accounts of the Mongol instruments mention very briefly a 28-fold 'zodiac or constellation belt' and also 12-fold and 24-fold star groupings. At the time when these were reported, little was yet known about a matter which has occasioned some controversy. Henri Bernard's study (1935) has resolved Ricci's confusion between Chinese equatorial and Moslem ecliptic divisions, and thus has made more possible the use of these star groupings as important criteria in the ancestry of instruments. The 28-fold grouping appears as a lunar zodiac in Hindu and other systems, and the several alternatives have been suggested of a Hindu origin with transmission to China, Chinese origin with transmission to India, or of the different civilisations receiving the system from some common source, probably Babylonian. But it is not difficult to prove that any such migrations must be very ancient compared with the times of which I write. There were in particular four groups determined by four stars in Hydra, Scorpio, Aquarius, and Taurus; these have been identified as the foundation of the 28-fold system from the time of the Han dynasty, and probably were then taken over from a much older system, about whose origin the following is the present state of enquiry. It was first suggested that the four stars must have been originally chosen as culminating at 6 p.m. at the solstices and equinoxes. On this hypothesis the group system must have been originally selected about 2200 B.C. But since at only one of these tropical dates could the culmination have been visible, Schlegel reinterpreted the natural origin as the date when these stars had respectively a heliacal rising at the spring equinox, a noon culmination at the summer solstice, heliacal setting in autumn, and midnight culmination in winter. This gave the unlikely date of 15,000 B.C., so de Saussure avoided the difficulty of invisible culmination by combining lunar and circumpolar stellar observation as a likely means by which the times of culminating were computed about 2000 B.C. Chatley, however, has shown (1938) that reasonable hypotheses concerning dusk culmination

on the four tropical dates can also imply a very likely origin of the system at about 1100 B.C., at the beginning of the Chou dynasty.

For our present purpose the important fact is that any of the above solutions of the controversy ensures that neither Moslems nor historical Hindus gave to the Chinese their star groupings. It is not, however, possible to decide whether these were indigenous or due to a Babylonian contact: the paper of Bezold to which I referred previously is suggestive rather than conclusive as to the scope of the undoubted contacts prior to the Han dynasty.

The 28-fold star grouping differs from the Greek, Moslem, and European, both in not being properly a system of constellations and in being equatorial. The groups contain any number of stars from two upwards, and are divided by individuals making unequal intervals in hour-angle and Right Ascension. Any star's position is determined by the time interval between its own meridian passage and that of a primary star in the nearest of the 28 groups. Zinner's comprehensive comparison of all early astronomical systems emphasises that Chinese measurements referred to the equator until the Jesuits arrived in the seventeenth century, and that the ecliptic in the Graeco-Moslem sense as a coordinate circle was scarcely ever used. Confusion with a zodiac, however, arises because the Chinese frequently regrouped the 28, sometimes into 12 unequal groups, sometimes into 12 equal divisions of the equator; the latter grouping of course bore spurious resemblance to the European system although still equatorial.

VII

Earlier Chinese Examples

Following any discussion of these features in which the designers of 1279 declined to utilise their ready acquaintance with Moslem technique, it would be of the greatest interest to trace a purely indigenous ancestry of Chinese instrumental types. But the destruction of predecessors in the Mongol conquest, and the close isolation of the Sung civilisation, leave scarcely any detailed evidence. The few fragmentary data which are relevant may be summarised as follows.

Immediate precursors of the instruments of 1279 were armillary spheres built in 1050 and some rather uncertain later dates. Of these designs the meagre traces of description extant suggest a close similarity to those of Kuo. It appears that the latter's new

observatory equipment is not to be taken as a radical innovation, but as largely occasioned by removal of the Sung capital, the previous instruments having incorrect pole elevation for the latitudes of the two new colleges founded by Ye-Lu-Chu-Tsai. In fact Chinese astronomical apparatus of the ring and sphere type is reported in the tenth, eighth, seventh, fifth, third, second and first centuries A.D. and the first and second centuries B.C. The brief details of the records imply the same fundamental principles as in the thirteenth century. Before then one hears with certainty only of the Gnomon, of which a specimen eight feet high is mentioned as used before 2000 B.C. But the shadow of a vertical, and the remarkable variety of astronomical information which it can afford, is probably common to all primitive scientific cultures, and so conveys nothing about the transmission of knowledge from one civilisation to another.

It is, however, significant that in the eighth century A.D. in China a sphere is reported as designed for using ecliptic coordinates in contrast to the usual Chinese equatorial system. About the same time a 360-degree and 60-minute circle is mentioned. Since Buddhist immigrations had introduced the Hindu numerals shortly before this time, we have definite signs that the science of the Nearer East was at least given temporary trial before being rejected for reversion to the older Chinese conventions.

VIII

Conclusions

It is a commonplace, not always capable of proof, that early Chinese science was diligent in original discovery but liable to freeze into conventions persisting unalterable over many centuries. In this chapter I have scrutinised a particular instance of this, in the contrast between some remarkable astronomical instruments and certain foreign designs to which their builders had ample opportunity of access. It is possible thus to test Chinese conservatism at an epoch when in some specific points of observatory technique its ancient conventions were still superior to the rest of the world, and when in other points it missed an opportunity only seized by the European astronomers of the Renaissance.

I have therefore examined some contrasts between these instruments and the conventions of Babylonia, Alexandria, India, and Moslem Persia and Syria, describing those observatory equipments shown capable of influencing the Mongol designers of 1279. The

result suggests that just at the era of readiest availability of western astronomical methods Kuo-Shou-Ching deliberately set aside the latter and reverted to a technique which had already been in use in Chinese astronomy for twelve centuries. I have distinguished certain features in which the Chinese methods were inferior to the contemporary Persian, and other features more close to present-day practice and antedating by 400 years the introduction of the latter from Europe. The surviving instruments of 1279 must therefore be accepted as quite independent of the great Moslem scientific age. Their nearest possible foreign affinities are among the Alexandrian Greeks known to the Han dynasty ten centuries before. They contain, however, certain notions which the Chinese seem to have retained from pre-Greek times, and which if influenced by any external source must be Babylonian.

At the time of construction of the instruments in 1279, contrast between retention of ancient Chinese methods and rejection of acknowledged Moslem science reaches its extreme in the duplicated astronomical boards, Persian and Chinese. Each appears to have had its own calendar system and instruments, but the records of the dynasty suggest that the Moslems fulfilled only a formal duty: they seem little more than embodiment of a convention perhaps maintained for political reasons and ignored in actual scientific work. If the two had genuinely combined when the Mongol rule offered unique opportunity, Chinese science might not have decayed to the level in which the Ming authorities failed to realise that a 36° pole elevation was unsuited to an observatory at latitude 32°.

So this enquiry into certain instruments surviving from the thirteenth century provides testimony to Chinese inventiveness: but the further enquiry into the ancestry of the instruments provides also a damning indictment of scientific conservatism. The modern world, struggling against similar intellectual vices in a scientific environment infinitely more complex, will only profit by such lessons in its early history if it recognises that conservatism is often accompanied by a meticulous precision in detail of observation and calculation. Conservatism may even be accompanied by capacity for real originality, sterilised by hesitation to follow the progressive instincts. All these features appear in the remarkable episode of the Mongol equatorials, where habits of mind productive of the best in art, craftsmanship, and moral philosophy, show how tragic may be their maladjustment to the needs of scientific research.

Chapter 13

Conflicts between the Logical and the Mystical Mind, from Ancient Chinese to Recent Europeans

I

In spite of some subtle similarities, the judgment which we employ in assessing the validity of a scientific theory must differ from our attitude to a work of art with imaginative appeal. Sensitive and exploratory minds for thousands of years have approached the major problems of existence either imaginatively or scientifically; occasionally, as in the Moslem and the Chinese civilisations, there was an unprofitable oscillation between the two attitudes, which is a lasting warning as well as inspiration in the history of culture. Since then there has grown up a recognised antithesis between the mystical and the logical. This antithesis is very similar to that between aesthetic and scientific, and may often be treated by interchangeable terms since the imaginative underlies both mysticism and art. On the one hand there are claims to acquire true knowledge about our environment by an intuition, the chain of mental antecedents to which is untraceable and seemingly a kind of 'short-circuit'. On the other hand are claims based on strictly verifiable proof, the chain of whose antecedents must be traceable and must be agreed upon by all concerned. Systems of religion, claiming ultimately to depend upon the intuitive, have often ceded their vantage by pretending to be supported by the logical: no modern science claims anything but logical support: the arts are as frankly imaginative: but systems of philosophy have often simultaneously made logical claims while utilising the intuition of the mystic, with or without certain shame-faced attempts at concealment.

It seems time that this possibility of dishonesty should be removed, and philosophical speculation judged as having an aesthetic and not solely a logical aspect. But in abandoning claims which belong exclusively to the latter, the former's title to be realistic and

not mere wishful thinking must satisfy instead the rigorous criteria of discipline and humanity which I have elsewhere shown may be learnt from the imaginative arts.

This possibility will be unwelcome in some philosophical camps: many progressive philosophers, especially the Cambridge school with the exception of McTaggart, have resolved otherwise the ambiguity between the logical and the imaginative. They have explicitly abandoned all attempt to formulate theories at large about the universe and human destiny, recognising that in the past such theories have been as easy to demolish as fascinating to construct; so they have pared down their historical heritage to a logical critique of scientific concepts. It happens that many of these logicians are temperamentally impatient of 'trying to see the universe whole', and our somewhat queer watertight compartments in education encourage students of the logical to dismiss the use of the imagination as suspected of trafficking in mystical delusion. But already the pendulum has swung too far: when we rightly shun the sentimentality in recent grafts of Oriental mysticism upon Western commercialism, we waste our inheritance if we also despise the honestly logical mystics who saw the scope and limits of intellectual enterprise, such as Plato, Spinoza, and McTaggart.

In search of equilibrium between these extremes, I propose here to offer data towards the possibility that philosophical systems of various scattered epochs have aesthetic value; I also suggest that this does not necessarily imply that the systems are wholly delusive. For the novelty of seeing such a suggestion without prejudice arises from certain discussions in which I have tried to find the common ground underlying the distinctions between science and imaginative art, and have admitted the genuineness of insight afforded by each, whether quantitative in the one case or qualitative in the other. Elaborated in some detail in accompanying essays was the following tentative point of view: imaginative art is a communication from artist to public through the medium of a pattern or structure in music, painting, sculpture, decoration, poetry, and requires a creative response on the part of the hearer or the beholder to develop coherent imagery. Though ultimately derived from that of the artist, this imagery will vary from individual to individual. Science is also essentially the communication of ideas by means of pattern, but here the different recipients must become capable of correlating precisely and quantitatively the mental images aroused in each; for the truth of a scientific theorem exists

in the identity of images verifiable by experiment and calculation on the part of different observers using comparable mathematics and equipment.

I shall consider in the light of these likenesses and differences some widely dispersed examples of imaginative insight which have been concealed under an unnecessary and misleading cloak of pretended logic. First there are the ancient Chinese philosophers whose thought primitively foreshadowed the systems of more sophisticated civilisations. Then there is Spinoza, hybrid between logician and mystic, whose position in philosophy has flickered between the dominating and the negligible because philosophers have vacillated over the status of the imaginative. Finally the same principles might throw light on certain recent thinking.

II

In the last six centuries B.C. and the first two centuries A.D. the intellectual and religious development of Chinese civilisation crystallised into certain lasting patterns. The importance of these is not destroyed by subsequent degeneration of the resulting institutions and habits into mere formalism and magical superstition. Interpenetrating with some of these developments there grew up traditions of art whose lesson to modern Western culture is scarcely yet beginning to be learnt. Taken at its face value, the flood of translated Chinese philosophy recently appearing in Europe and America can only present a bewildering mélange of nonsense interspersed with common-sense or even commonplace. To reduce to the comprehensible by absorption of the mental background, demands pursuit of endless verbal allusiveness in a language where multiple implication makes ambiguity almost inevitable; it is a task enormous and seldom attempted, though the writings of Arthur Waley have made a beginning for English readers. Perhaps the most striking pioneer has been I. A. Richards, whose study of 'Mencius on the Mind' opens the way to a mode of treatment which might yield new understanding out of ancient and medieval thought from Plato to the Neo-Platonists: it might even be applied to Spinoza and to moderns as far down as McTaggart yesterday. For we have been too accustomed to expecting a Western writer to expose his whole significance in a single dictionary-meaning of each word or sentence, and we miss what value we might capture until we approach the Orientals in the manner of Richards, with

painstaking research into all of an author's possible implications and underlying mental attitude.

The facts, so far as they can be extracted from much overlaid prejudice, are as follows. The complex interwoven fabric of the Chinese attitude to nature and human nature was derived from three main strands.

(*a*) The most fundamental was perhaps the visionary mysticism associated with the name of Lao-Tzu, which later hardened into Taoism and degenerated into magic, but which originally grew from a number of scattered schools of thought between the sixth and fourth centuries B.C. Chuang-Tzu and Lieh-Tzu are authors much quoted in the later Taoist literature and possibly were actual teachers in the third or fourth century B.C., but whether the somewhat legendary Lao-Tzu wrote the collection of sayings called the Tao Te Ching is now doubtful: it is not in any case a very voluminous canon for its extremely widespread historical consequences. These schools all shared a common tendency to regard material considerations as superficial and some sort of spiritual life as the more permanent reality. A rigid self-discipline was practised, which enabled superiority over many of life's vicissitudes to be attained with a success not exceeded in the religious enthusiasms of subsequent ages and other countries. But traditional tales of the Taoist control over external as well as internal nature are obviously picturesque exaggerations of the familiar 'miracle' type. The philosophic basis is clearly the earliest historical example of what was called Pantheism in later civilisations, the insistence that we partake, in common with all things, of an all-pervading spiritual nature through which is available the help and sympathy of superhuman as well as subhuman 'life'.

(*b*) Chinese philosophy is a complete scale-model of the natural contrasts in human intellect; so it is not surprising that parallel with such mysticism from the earliest centuries of Taoism there ran the severe practical code of public duty associated with the name of Kon Fu Tzu (Confucius) which has often been described by the ignorant West as a religion. There were also frequent intellectual movements which can only be called cross-breeds between Taoism and Confucianism, and involved partial revivals of the nature-worship which had solidified centuries earlier into a Dualism or ascription of natural phenomena to the interaction of Yin and Yang. These twin principles, crudely misdescribed as Male and Female by European commentators, appear in the arts and ceremonies which survived from the third millennium B.C.

Mencius, living in the fourth or third century B.C., represents some of the systematic philosophising which developed out of the more personal teaching of Confucius two centuries before him. Reactions against each of these, the visionary and the practical, led not only to cross-bred systems of morality or of mysticism, but to extremist offshoots such as the violently legalist and the violently hedonist and the violently pacifist sects or schools of thought which flicker in and out of Chinese history. But the two strands of Taoism and Confucianism divide between them a large proportion of what man has always tried to express in his many attempts at religion, and they maintained a hold even in extremely debased form until the present century.

(*c*) Compared with these indigenous ways of approaching the universal problems of worship and conduct, the third constituent, Buddhism, was an import from India during the Han dynasty (206 B.C.–A.D. 220). This ultimately exercised as great an influence over Chinese arts and sciences as Taoism and Confucianism. But even the earliest immigration of Buddhist teachers, and the many subsequent arduous pilgrimages westwards in search of Buddhist scriptures, failed to prevent the Chinese temperament from instantly modifying the somewhat humourless Indian flavour. Finally, in the sixth century A.D., there was completed a still more radical transfiguration of the foreign element, and the Chan type of Buddhism thereafter appears as a grafting of Taoist monastic ideals on to a rationalised Buddhist foundation. The austere mystical convincement of a spiritual universe, the self-discipline conferring harmony and power over that universe, were softened by the more personal Chinese version; there spread the legend of the saints who attain enlightenment but who renounce heaven to yield themselves to the service of suffering humanity. Typical is the embodiment of the spirit of compassion in Kwan Yin, the madonna and child familiar in miniature Chinese carving. The theory of reincarnation from the original Hindu Buddhism also appears in the Chinese version, but Nirvana is no longer a mere negative attainment or annihilation.

Such was the philosophic and religious background to a strange intermingling of arts and science. In other chapters I have stressed the warning which must be inferred from the paralysis of science in Oriental civilisations when misfitted to aesthetic conventions. But philosophy must take account also of aspects of experience which are not susceptible of quantitative and scientific description: it will be a task of a coming generation to see where more adequate

adjustment can be reached between the logical, the aesthetic, and the mystical. For this task the combination of crudity and profundity in Chinese thought offers invaluable data.

III

If Western historians had not dismissed Oriental thought as inaccessible and, when partially accessible, as primitive, we would not have failed to see in the ancient Chinese the prototype of most religions which employ monastic practice or mystical or pantheistic ideals. Such ideals permeate much Christian Catholicism as well as miniature experiments in mystical worship as practised for instance by the Quakers. Nor would we have failed to recognise in the long history of Western philosophy, running from Plato to the present day through the Neo-Platonists and Giordano Bruno, a strain with remarkable similarity to ancient Chinese thought. The rarity of contact between East and West, and their historic tendency to mutual contempt, precludes our demanding culture-migrations to explain this likeness: but it does suggest that there are some extremely widespread roots in the human mind, which exhibit life and vitality in many environments and many stages of history. Their vitality appears sometimes in attempts at logic, sometimes in attempts at the mystical approach to enlightenment, and sometimes expresses either or both in some form of art. Much that is of vital importance to human happiness, and must be omitted from a philosophy confined to analysing scientific concepts, requires a radical but not unphilosophical revision of the rash barriers erected by our education between the scientific, the artistic, and the religious. But a rigorous scrutiny, far stricter than needed in the past isolation of these three aspects of human enterprise, will be needed to avoid the misfits to which I have drawn attention in this and other essays.

As tentative suggestion of the cross-classifications required, take the case of Spinoza, the Dutch excommunicated Jew of Spanish descent; I propose the novelty of regarding him as primarily an artist with a perversely scientific style, rather than as exclusively a philosopher. The ambiguity which has tickled or irritated subsequent generations from his own seventeenth century until now, indicates our ineptitude at recognising under scientific theorems a religious and an artistic instinct which would have been at home in an early Chinese dynasty. For some have called Spinoza an atheist, and others have called him the most God-seeing man in

nature concerning its destiny. I find one step wrong in this turn taken by modern English philosophers, not that they recognise the weakness of constructive logic, but that they infer from that weakness that no access whatever is possible to the major mysteries: centuries of artificial separation between science and the aesthetic attitude have lost to them the possibility that the imaginative may offer clue to the real.

The last, and greatest, of those who proposed by logic alone to create new knowledge of human destiny was McTaggart, the twentieth-century counterpart of Spinoza, though he himself would not have recognised the kinship as clearly as within a few years after his death a spectator might see it. The interpretation of what Time must mean has emerged, since Spinoza, as the focal point of philosophy, and McTaggart alone of all his intellectual ancestry explains why Time becomes so important to us although some part of our ultimate aim must be to supersede it by 'aeternitas'. His elegant conception of the past-present-future sequence and the before-and-after sequence with a real but timeless sequence underlying them, is perhaps the most ingenious logical pattern ever constructed in philosophic history. Needless to say, it carries within it the inherent weakness of this artist's vulnerable medium of expression: for McTaggart is surely an artist as was Spinoza and as were the ancient Chinese. Logical demolition of his entire system has already been carried out with rigour by Broad in his three volumes of commentary. And yet, like the work of all imaginative artists, we have not disposed of its significance for communicating an image to the receptive mind by saying 'it cannot be proved true'. What escapes the net of our very imperfect intellectual equipment is not always delusive, though the criteria for imaginative forms of expression must subject it to as drastic a critique as the laws of logical validity of proof. If formulations not scientifically expressible can pass the most rigorous test of being good art, a revision of categories and an abandonment of hasty claims may yet allow philosophy to recognise both, the aesthetic and the logical, without withholding from either any title of 'real' conferred upon the other.

V

I have submitted in earlier chapters that much primitive science was ruined by overestimating the legitimacy of any mutual influence between logical and imaginative judgments. It is argu-

able that the acutest problem now facing contemporary philosophy is to escape an inversion of the same fate, and to utilise scientific method without abandoning tasks to which that method is inadequate.

In ancient and medieval and early modern cultures, scientific method had not clearly emerged from among other intellectual tools, and no distinction was drawn between its applicability to one and another phase of experience. Today there is the opposite danger that philosophers often despise those aspects of experience, the ethical and aesthetic and religious, which are too closely grained to become detectable in the analysis that we have perfected for the physical sciences. To avoid the blindness of that arrogance we must learn to distinguish the occasions on which we are 'philosophising' in the sense of analysing scientific concepts, and those other occasions on which we are 'philosophising' in the sense of recognising that the modern mind is both logical and imaginative but neither exclusively.

In the next chapter I am concerned with one particular application of this distinction, but it is of infinitely wider importance. It might possibly in the future cut across some traditional academic compartments of study, and allow a revaluation of Plato, Spinoza, McTaggart, and the early Oriental mystics.

Chapter 14

Symbolism as a Future Clue to Conciliation between Science, Religion, and Art

I

Introduction

In a troubled age, when the needs of public safety must absorb so large a proportion of available effort, we may well take thought to eliminate some of the wasteful sources of disharmony in human relationship. One of the most disastrous of these has been the habit of treating our divergent beliefs about nature as if one of them were right and every other were wrong. Throughout history there has been no cruelty more merciless than that practised by orthodox religionists upon heretics or unbelievers, and when we have emerged from such barbarism there still survives the sour suspicion with which religious and scientific, the mystical and the logical temperaments, tend to regard one another. Even between closely neighbouring religious bodies, toleration of unfamiliar beliefs is a new and rare virtue, not always distinguishable from a mere softened contempt; so it is not likely that the more subtle possibilities of sympathetic agreement between a scientific and a religious outlook will be easy to recognise, and indeed any such possibility is commonly ignored and peace only maintained by an aloofness of mistrust. But if the method of scientific observation itself were utilised to discover what similarity of foundation may underlie a great variety of religions, the results might contribute to mutual respect so long as they were presented without the traditional hostility. In searching for such foundations, I suggest that most manifestations of the religious attitude to nature are attempts at symbolising a certain kind of experience: the suggestion arises from considering, as follows, certain phenomena which are accessible to observation by anyone.

II

The Fact of Worship

2. In a scientific approach, indeed upon any rational plan, it is important to separate the facts from their diverging possibilities of

interpretation. The facts here relevant are so widespread or even universal, that ecclesiastical organisations have not been willing to recognise them as essentially religious, since such recognition would abolish the monopoly claimed by any one historic church. Nor have they been regarded as facts of religion by those thinkers who are hostile to all ecclesiastical organisations and who strangely arrogate to themselves a monopoly of the title 'rationalist'. Once these two kinds of prejudice are relaxed, there may be uncovered a wide territory of experience which is shared by many who as 'believers' or 'unbelievers' have been artificially and unnecessarily separated. I propose first to consider the meaning of the term 'worship'; in the poverty of language this word serves to describe a group of psychological facts transcending many of the differences between theist and non-theist, and it denotes an attitude more fundamental than 'belief' and 'unbelief'.

3. It happens to nearly everyone occasionally to find himself appreciating a situation not solely according as it gratifies instincts of self-respect or sex or domination, and not solely because it offers escape from fear of insecurity or want. The recollection and anticipation of these experiences is cherished profoundly and intimately to a degree not adequately expressed by the label of Good, True, or Beautiful, and devotion to them is as reckless of gain and as unquestioning as a parent's devotion to an invalid child. In fact, response to such moments of illumination has an intensity not accounted for by arguable judgment and not publicly justifiable, and it constitutes an attitude which we can only describe as 'worship'. Any kind of experience which evokes this attitude we can suitably call 'holy' or 'sacred'. In terms of this fact of experience we invert any definition implied by tradition and we say that The Holy is 'that which someone worships'. Obviously these words must not be limited to the belongings of any religious institution, for some of the most memorable of such occasions are encountered in contemplating works of art or natural beauty or personalities of a historical past or contemporaries to whom we have given affection, honour, and devotion.

4. From the point of view of a spectator, concerned with an external view of these facts in the Natural History of human behaviour, the 'thing' which is worshipped is the actual experience itself, or the bare commonplace that to each of us those sacred moments do occur. But we are all worshippers at times, including those of us who are also scientists, and we have spent several thousand years trying to give a name and a description to some-

thing which most men have elected to consider as outside ourselves —the 'object' of the worship. To worship, and to treat some portions of our experience as holy, belongs inevitably and undeniably to all of us, whether we choose to call ourselves Christians or atheists or anything else whatever, and in this sense none of us escapes being religious: differences between us arise, however, as soon as we enter that age-long competition to give a name to the 'object' of our worship. Some avoid this competition and call themselves agnostic; it would be a mistake to imagine that these are necessarily irreligious merely because they refuse to become theological.

III

Symbolism

5. One degree further of general agreement might well become possible, whatever interpretation we elect to give or to withhold when the 'object of worship' is discussed: I suggest that much unhappiness and bewilderment might be eliminated, if both the scientific spectator and the worshipper were to recognise that through all those ages we have been searching for mental pictures or 'symbols' to maintain in our recollection this elusive experience of sacredness. From time to time, these attempts to symbolise the common experience become conventionalised into systems of religion, the organisers of which are forced to undertake the impossible task of giving precise and unambiguous meaning to deity.

6. If we thus recognise that all men tend to hold before their attention some symbol of the experience they find sacred, the differences between the interpretations of worship for the orthodox, for the agnostic, and for the 'atheist' become more simple: they reduce to differing implications of the word 'symbol'. Although it is highly irrational to call oneself an atheist, meaning 'I have proved that there is no God', since such proof is obviously more than anyone can honestly claim to achieve, there are many who are not convinced that the symbol is anything but 'mere' symbol and a figment of the imagination. The not dishonourable name of agnostic is here applicable. But there are many others to whom our symbols are an attempt to grasp a divine personality towards which we struggle in the universal dimness of human frailty of intellect. These others venture a deliberate willingness to trust the possibility of being given closer insight as the individual and the

race progresses: an act of faith achieved by many of the strongest characters of history and of today. I shall later suggest that both the attitude of faith and the attitude that nothing behind the symbol can be proved, are each legitimate: they can even be found in the same person, so long as the domain of faith and the domain of proof are recognised to be both essential but different constituents of our mental outlook.

IV

Consequences of the Recognition of Symbolism

7. Before enquiring further whether such paradox might not serve to heal the historic incompatibility between the scientific and the religious, consider some general consequences of admitting that religious expressions are symbolic of the common experience of worship. Recognition of this fact will certainly account for the infinite variety of our gods, from the nature-spirits pictured by primitive man to the impersonal Absolute of the sophisticated, and not excluding the many shades of divinity recorded in the literature of Christianity and other highly organised religions. Recognition of the universal tendency to symbolise may also restrain us from foolishly concluding that any gods other than our own are false gods: for the symbols or images occupying different minds will vary greatly even when they represent experiences which are not so dissimilar. But of one certainty we must definitely be convinced by this variety in our ways of describing God: that the terms in which we picture or symbolise our object of worship are essentially individual and incommunicable and private to the temperament of each experient, and are even modified from the occasion of one experience to that of another. No universally accepted and scientifically demonstrable account of deity will ever be propounded. This is not such a privation as our ancestors feared in the days when they imagined that to 'prove the existence' of God was an act of piety; perhaps we have acquired the humility to recognise that he would be scarcely divine if he were so completely within the grasp of our primitive logic. It is healthy to admit in theory what we have all accepted in practice, that we need not await a perfected theology before worshipping, any more than we await a conscious reason before committing ourselves to the intimate adventures of aesthetic inspiration or human affection.

8. The religious portion of any man's character, thus freed from obligations to argue its faith save with its own sense of honesty,

also loses the right to be exclusive and the call to proselytise. In early ages, conformity was judged by ritual, and in later ages by creeds; but if the present suggestion is correct, religions differ chiefly as individual temperaments find one or another mental picture better for facilitating the maintenance of that subtle and indefinable sense of holiness. Differing accounts of God are then no longer mutually incompatible, and 'belief' becomes not the underwriting of an authoritative doctrine, but the earnest attempt of each of us to create the most vivid of those mental pictures or symbols. For without our efforts to symbolise, the most sacred aspects of common experience would fade too soon from the scattered attention of us ordinary mortals. This lays upon us the obligation to play each his own part as creator as well as worshipper: 'God made in our own image' implies not a blasphemy but a universal command, which we can none of us escape without courting the death of the spirit by atrophy of its main function.

9. In contrast to the most tragic feature of religious history, the more honestly we recognise as our aim the pursuit of our own particular symbolisms, the less shall we be tempted to attack the different symbols created by others. It was an error of short-sightedness to suppose that science would ever destroy the religious spirit, but it does destroy the intolerance commonly exhibited by followers of any one religious institution towards followers of any other. For if science without a touch of mysticism is blind to many aspects of nature, mysticism untempered by scientific logic is unbalanced and undisciplined and is apt to degenerate into cruelty, forgetful that all symbols have equal right to devotion, and rest equally upon no proof but individual creativeness.

10. In using the word 'create' I deliberately ascribe to the religious attitude the prerogative of the artist. Not all of us are privileged to exercise in music or words or colour or material structure the faculty of weaving such a pattern of ideas as can rouse the imagination, but inasmuch as everyone is at some time religious he is also in those moments the artist. So it is as true to say that the artist in each of us fashions the symbol or image of God as that God the artist makes man in his own image. Actually the imagination has been too little recognised for its part in worship, and has been curiously despised even when recognised—perhaps through the rather primitive psychology which classified the imaginative as necessarily the antithesis of the real. This classification, fortunately, we outgrow as soon as we regard the

penetrating insight into human fears and hopes shown by the most imaginative of artists in any age from the ancient Chinese to de la Mare today.

V

Status of the Symbolic and the Real

11. We now confront the divergence of interpretation to which the notion of symbolism has led. I have called the idea of God a man-created symbol held in our minds to represent or to explain the fact that we all find ourselves worshipping. But do we thereby imply any suggestion that there is nothing more behind the notion of deity than a figment in the brain of the worshipper? The non-theistic interpretation follows such a suggestion by being impressed with the impossibility of proving an existence inaccessible to sense-perception, and by forgetting that the faithfulness and affection of our every human friend is equally unprovable. On the other hand the theistic interpretation is wise to admit the implication of the theory of symbolism, that the reality of each symbol is individual, incommunicable, and therefore not publicly provable. The theist must be willing to hazard his courage as an act of faith, just as we all plunge into the unknown and unguaranteed in every venture of human friendship.

12. The question of the real external existence of the object worshipped is therefore in one sense unanswerable, and in another sense can be answered by the courage and enterprise of each individual worshipper. In any scientific sense of communicable proof it is unanswerable either by affirmation or by denial and we are all agnostics, neither theism nor atheism being capable of logical guarantee: but in the privacy of each of our personal experiences it is legitimately answerable with innumerable shades of meaning according to the metaphysical temperament of each one of us. Our individual convincement need not be diminished when we discover that none of the answers is likely to carry conviction to anyone else, unless to someone of identically similar mental background. We crave for public proof only if there is risk that God the Symbol be regarded as 'mere' symbol; but this risk only arises when we make futile rebellion against the limitation of our nature which restricts us to approaching such abstractions as 'sacredness' through the medium of symbols only. This is a limitation which neither the most faithful in devotion need want to penetrate nor the most arrogant in missionary zeal can claim to

override. In Biblical phrase we are only able to 'see through a glass darkly,' and much of the cruelties in the history of intolerance would have been avoided by taking this phrase seriously. Those other Biblical phrases, that the kingdom of heaven yields only to a childlike approach, are perhaps another form of the same warning; when we were children, imagination and 'reality' had not the artificial separation which arises in the sophistication of civilised life, and we need to outgrow the first arrogance of that sophistication before we can regain the early vision of the imagination. This regained, we shall perhaps cease pretending to probe the unseen linkage between the symbol which we create in our mind and a deity of whom we are not to be given demonstrable perception in this life.

13. The 'reality' associated with any religion has a further meaning when judged by its practical consequences. For instance, the most important historical example of symbolisation seems to me the new choice that Jesus made when he pictured the indefinable object of worship as 'Our Father', and whenever this particular symbol has been sincerely regarded there have been profoundly practical consequences, because a God expressed by Fatherhood demands a brotherhood of fellow-men. This example of symbolism, in addition to its great practical importance, serves also to remind us that there is nothing derogatory in referring to any description of deity as a symbol or mental image. For the description chosen by Jesus, that God is only knowable as The Father, is surely a symbol, since no-one has ever suggested that this term with its connotation of biological race-propagation and social legal contract is to be taken literally. But the countless millions who have always taken it as symbol have not thereby deprived themselves of the resulting comfort or foolishly despised it as 'mere' symbol. To accept the symbol imaginatively instead of literally does not prevent it being an approach to a reality with which we may later in our evolution become more closely acquainted. To certain temperaments and races, for example Chinese, the 'Way and Power' of Taoism or the 'Path' of Buddhism have differently symbolised the same universal sacred elements in experience, and religions based thereon must no more be despised for their subsequent degradation than Christianity is to be rejected because Christians so frequently fail to carry out the logical consequences of brotherhood.

VI

Religion as Prayer

14. If the incomparable perceptiveness of Jesus found fatherhood to be the likeliest symbol of his discovery, no one need ever doubt that the most-treasured link of human affection is open to all of us in consequence, and that prayer to the divine Father may become as real as communication with a loved and mortal parent. But, as before, we must not fail to distinguish between facts which the conscience of the individual finds real and the fewer facts which nature permits him to demonstrate to others and therefore to incorporate in a scientific description of his universe. Prayer is undoubtedly the 'practice of the presence of God', not merely on isolated occasions when we all cry out in longing for wish-fulfilment, but throughout a life consistently orientated towards whatever we regard as the divine will: but the judgments made by observer and by participating worshipper regarding this practice must diverge. From the point of view of the external observer an 'answered' prayer cannot be anything but the autosuggestive effect that an intensely feeling personality may produce in his own mind by meditation, together with perhaps some subtle but powerful telepathic effects in other minds concerning whom he meditates. The praying worshipper, however, is equally justified in maintaining in his own private consciousness a radically different interpretation: he ought to remember that his experience is no more publicly disprovable than provable, and that there exists no scientific reason whatever to forbid him assurance of his direct communion with something in the universe so personal as to be understanding of his troubled hopes. It is one of the tragedies of civilised thought that these two aspects of religious communion, that accessible to the outside observer or scientifically describable, and that only accessible in the very attitude of prayer, have become confused so that the inherent impossibility of demonstration has weakened the instinctive trust in prayer. Fortunately no such weakening is necessary: when we all exercise our heritage of the child calling out in fear of the dark, the divine answer is for each of us alone, according to the faithfulness with which we create and cherish our particular symbols or gods. It is not to be held up for public exhibition, but this limitation is of the course of nature and ought never to silence our praying or drive us to a needless despair.

15. This Natural History of religion reveals not only the com-

mon feature of symbolism which we all pursue, whether we choose to call ourselves theists or non-theists, but also the universal distribution of these instincts of prayer. For the race-memory of communion with something more lasting than ourselves is older than any orthodoxy; modern Catholics or Quakers who value meditation often fail to admit that their practices are identical with those of many ancient Chinese quietists, Buddhist monks, and medieval Persian Sufis, as well as the Spanish and other geniuses of Christian monasticism. All these, in the Biblical phrase, learnt to 'walk with God'. In more modern scientific phrase they were outstanding examples of integrated personality, and the two ways of reporting the same phenomena need not be at all incompatible. To the external observer the net effect is that the praying individual behaves as if he were a channel though which unnatural forces are exerted. We may some day learn that it is a contradiction in terms to call the divine unnatural, but at present we can only admit in dim ignorance that powers are utilised with astonishing curative effects in mental and physical disease. Prayer and meditation can in fact become the most practical of all activities; this is especially true for that most urgent and insistent 'Thy will be done' by means of which 'Thy kingdom come' does begin to attain its slow painful stages towards fulfilment, when once we rid ourselves of the fallacy which imagined that such prayers imply a passive acquiescence. In struggling for this fulfilment, many of the saints of all religions have in the past lived dangerously and thus 'walked with God', and in honour of their example even we might be glad to live precariously and to die without wasting energy upon anxiety or complaint. Without any call to withdraw from any world, the lost monastic ideal might permeate each of our many secular occupations and enable these to be carried out in the constant mental attitude of worship and prayer, summoning up powers beyond our understanding, through our devotion to a symbol of something sacred, unseen and undemonstrable. In the end we should not fail to attain the vision splendid, in spite of whatever disaster, and even to reach the peace of God, and without any attempt whatever at propaganda we might be not without some effect upon our generation.

PART FOUR

Leonardo da Vinci as Scientist in Art: his fantastic Drawings and the Prototype of Scientific Uneasiness in an Unscientific Community

Chapter 15

Introduction

The possibilities of common interests for science and art hitherto discussed have depended upon similarities and differences in aim or method; the dangers exhibited historically arose in communities where scientific, artistic, religious, or philosophical enterprise had been ruined by failure to recognise these differences or to utilise the similarities with due regard to where they begin and end. But a certain unique example of individual personality remains to challenge any denial that within a single character the imaginative and the scientific could ever be synthesised: the mutual destructiveness of artistic and logical effort seems to be in abeyance for Leonardo da Vinci, and the intellectual balance to be as perfect as for anyone known to history. This remarkable individual is nevertheless one of the outstanding historical cases of frustrated allegiance, and the nature and source of his personal disaster may be of importance to the future relations between art, science, and society. The following chapters express a conviction that here was no maladjustment between science and art, as too often supposed, but between scientific philosophy and the habits of civilised society. It is conceivable that in Leonardo's tragedy may be found the clue to the only irreconcilable left when science, imaginative art, and religion have achieved mutual understanding.

The moral status of a scientific outlook, in a world burdened with the misuses of technology, raises problems no less urgent than the impact of science upon religion and philosophy. It has not yet been widely realised that Leonardo da Vinci, to earlier generations an object of curiosity as to the freakishness of cross-breeding

between science and art, is a clear prototype of the incompatibilities which face the scientist in adjusting himself to an unscientific civilisation. I am offering some reasons for believing that the extremely imaginative phases of his art are documents of this adjustment, and thus are highly relevant to the rising urgency of our own intellectual and ethical predicament. To start out from an enquiry as to the effects of Leonardo's science upon his artistic expression, is in this case to end by discovering not only his peculiar sensitivities but the source of his deepest feelings, and possibly of our own.

A radical re-orientation of traditional approaches to Leonardo will be required for understanding his significance relative to the logic and imagination of our present battered civilisation. It is possible that too many of the accepted commentaries on Leonardo have been written by art critics concerned with his paintings and later with his drawings. Analysis of his scientific achievements by scientists and historians of science has followed more slowly. But between these two separate preoccupations, the mutual interaction of artistic and scientific temperaments in him has commonly been ignored, except for scattered details and for the complaint which descends from his contemporaries that he wasted in science the potentialities of his artistic genius.

Today such points of view are all too narrow. Since recent advances in communication have distributed so universally an interest in the arts, and since the consequences of a scientific civilisation are scarcely anywhere escapable, the meeting point of scientific and artistic outlooks ought to constitute a subject of enquiry of almost daily application; it offers unexplored territory rich in data even to those who do not pretend to comparative psychology. In Leonardo might be found the archetype of all such data: the simplicity of the Renaissance world is capable of revealing them in elemental form which would not so easily be isolated in the complexity of modern science and the more rapidly changing artistic fashions of the present day.

In the course of the present initial approach to Leonardo's significance for current science and imaginative art, it will be obvious that debts to many writers are too frequent for separate acknowledgement at each point. In particular the works of Berenson, Sir Kenneth Clark, Holmes, McCurdy, Hind, Ravaisson-Mollien, Müller-Walde, Richter, Popp, Hildebrandt, Müntz, Seidlitz, Heydenreich, Solmi, Calvi, Sirén, Thiis, Suida, and the Reale Commissione Vinciana and of historians of science such as

Séailles, Duhem, Grothe, Feldhaus, Hart, McMurrich, Thorndike, Sarton, Singer, have been gratefully consulted, though not always followed in opinion. Personal debts to Sir Kenneth Clark and to the authorities of the Royal Library at Windsor must particularly be recorded. The attempt to distinguish between genuine and spurious in the many hundreds of relevant drawings, seriously begun by Morelli, has been put on a chronological foundation by Clark, prior to whose 1935 Catalogue any understanding of Leonardo through the drawings would have been hopeless to attempt.

Chapter 16

The Problem of Leonardo's Imaginative Drawings

Effects of Technical Knowledge and of Temperament

The adventurous and often disastrous history of the works of Leonardo da Vinci, and of his possessions after his death in 1519, has left the modern world with less than a dozen paintings. Some of these are of doubtful authenticity. There also survive many hundreds of drawings and over five thousand pages of MSS. Many of the latter are illustrated notes on scientific researches. It is a commonplace that the artistic status of the drawings is high even when compared with the greatest products of the Italian Renaissance, and that in subsequent centuries of modern science many of the most striking advances find themselves anticipated or foreshadowed in those remarkable note-books. The present generation, surrounded by its own scientific achievement and now equipped with the work of so many laborious editors of Leonardo MSS. and drawings, is tempted to ask whether such art can have been the result of a scientific attitude to life or whether such foreknowledge of modern science can have been due to its author's needs and experience as an artist. If this question could be completely answered we should find ourselves solving one of the major perplexities of this century, as we should begin to see some of the stages of mental and moral evolution towards which an age of science is likely to tend.

The problem of interaction between Leonardo's science and art is thus of greater practical importance than the settling of a psychological detail in the history of the Italian Renaissance. It may clear away much initial obstruction if we mention briefly some reasons why this problem is by no means hackneyed; in fact to propound it may even be thought either rash or unnecessary.

Historians of science, conscious that their equipment is inadequate for appreciating the art of Leonardo, have often accepted the inadequacy as excuse for ignoring the artist in him when they try to understand the scientist. Art critics have been correspondingly tempted to ignore the scientific element in his character.

Such omissions can only mislead a modern reader interested in Leonardo as combining scientific with artistic temperament. In the end such a reader becomes irritated at the bewildered reverence with which the scientific historian dismisses Leonardo's art, and the vague respect with which the art critic dismisses Leonardo's science; he decides that neither writes with sufficient confidence for him to assess any influence which the one product may have exerted upon the other. He may even consider it prudent to restrict his scrutiny to specific details in which some piece of scientific knowledge affected Leonardo's technique in art. Obvious examples are his anatomical exactitude in human or animal or plant drawings, the deplorable effects of his curiosity in the chemistry of painters' materials, the skilled engineer's grasp of mechanical problems in his architectural designs, and the expert geology of his scenery. Much has already been written along those lines. But somewhere, in a scientific age, a more subtle enquiry must be opened, into more general effects of science upon a scientist's own perceptual and emotional development and character. It is here that Leonardo offers a difficult but uniquely promising opportunity, because this scientist had a power of expressing in his thousands of sketches many aspects of his own mental evolution.

Some tentative prolegomena towards investigating the effect of science upon the scientist may perhaps emerge from the present contribution.

Not all commentators on Leonardo would admit the necessity for my enquiry, as several recognised attempts to assess his mental peculiarities have discounted the personal reactions of his science. For instance in the well-known psychological studies by Freud and by R. A. Taylor, the former considered Leonardo's science as consequent rather than as antecedent in his emotional pathology, while Taylor considered it as a by-product of his art. The authority of distinguished scholars such as Thorndike has even been associated with views of Leonardo as the dilettante, implying only secondary interests in science. Hence an essential step in my argument is to apply the researches of Séailles, Duhem, Feldhaus, Hart, McMurrich, and others, to decide whether the universal application of scientific method was a primary aim throughout Leonardo's life, or whether it was only occasional and merely attendant upon artistic requirements. Richter. Holmes, McCurdy, Singer, and others have already recognised that Leonardo was a supreme scientist as well as artist, but we must find whether there

is any need to go beyond them and to describe his art as the self-expression of an inherently scientific mind. Any such view would intensify the loneliness in which he bridges the gap between Greek and modern, and might seriously affect the emotional consequences which must be attributed to his solitude. These emotional consequences may well have been expressed in his art.

Psychological analysis of any peculiarly scientific temperament is still in a very rudimentary state today. But there is so much in Leonardo that is foreign to his environment and nearer to the outlook which we are now learning to acquire in research, that a modern scientist has no difficulty in recognising the underlying attitude to experience. It is in this fact that I find some excuse for suggesting that the working scientist may contribute towards understanding the mentality of Leonardo: the contribution may ultimately be not entirely irrelevant in understanding the art of Leonardo.

Interpretations of Emotion in the Art of a Scientist

One dangerous ambiguity makes it especially difficult to interpret the artistic work of a scientist, and requires caution from the outset. Approach to the character of any artist encounters an uncertainty as to whether his works express mainly his own feelings or the feelings of others observed by himself. This uncertainty is apt to be unfairly resolved when the artist is described also as a scientist. For it is then implied that he is more interested in causes than impressions, and this leads to underestimating the strength of such an artist's own feelings. Thus it is usual to picture Leonardo as analysing a situation objectively or from outside, and such scientific attitude is liable to be described in terms suggesting that he was lacking in emotion himself.

In avoiding the danger of this suggestion, it is not necessary to insist on any particular theory of aesthetic: we have no right to pretend that honesty in observing nature is the prerogative of the scientist alone, nor to pretend that we have decided whether art is mainly the recording of the externally observable or mainly the communicating of the observer's response. We only require to be free from the common assumption that the more accurate the observer the less capable he is of personal feeling, or that the rational elucidation of causes need destroy emotional response to effects.

An immediate application of this caution is called for when subjects treated by many other artists are compared with Leonardo's

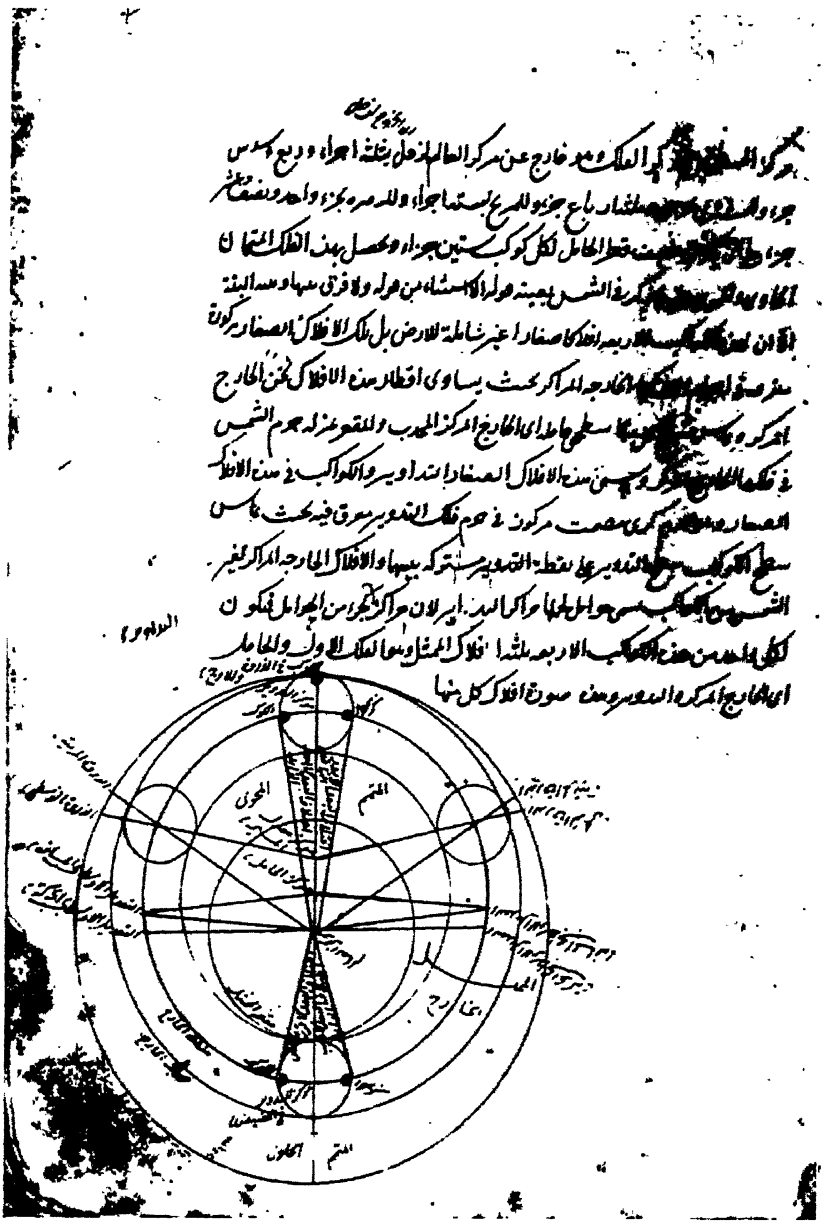


PLATE 11. EPICYCLIC ORBITS IN A MEDIEVAL ARABIC MS.

By courtesy of the late Dr. Mingana

PLATE 12. PROFILE OF A LADY
Silver point drawing at Windsor

own version. For instance, among representations of the 'Last Supper', that by Leonardo is undoubtedly the one most intensely suggestive of emotion. All those violent feelings had certainly been studied from a standpoint sufficiently detached to enable him to analyse and classify them. It is indeed legitimate to contrast him with any artist who was carried away by his own uncontrolled feeling and unconsciously submerged in it the personalities whom he depicted; for example, at two opposite extremes, the gentle piety of Fra Angelico and the tense and superb arrogance of Michelangelo are inescapable in their painting and sculpture. But this legitimate contrast only enforces the correct acknowledgement that Leonardo was capable of some degree of impartiality while actually painting and drawing; it leaves undecided two divergent alternatives, (*A*) that the emotions depicted, suggested, or symbolised, had been observed by him solely as they appeared in other people, (*B*) that those emotions had been experienced either immediately or distantly beforehand in his own person.

It is probably only the rare scientist among artists who ever tempts a critic to fit him with (*A*) to the exclusion of (*B*). Actually Leonardo the complete scientist might have been an external observer of behaviour or a violent participator or both, and so might answer to either alternative. But Leonardo as man or as artist becomes a quite different personality according to which alternative is emphasised. This essay attempts to throw some light, from his intellectual ancestry and his surroundings, upon the ambiguity. Meanwhile the use of adjectives 'cold' or 'dispassionate', in describing his scientific habits, must be suspected of begging the question.

Contrasted Types in the Drawings

Drawings have one great advantage over paintings since they suffer less by reproduction, so that a considerable acquaintance with Leonardo is more widely accessible than in the case of many artists. There are available in most large English libraries the six hundred small-size reproductions in Clark's catalogue to the great collection of Leonardo drawings at Windsor. The smaller volumes edited by Popp, by Hind, and by others, together with the sections dealing with drawings in the large treatises on Leonardo by Sirén, Müntz, Hildebrandt, etc., reproduce many examples from Windsor and from Oxford, Chatsworth, and the French and Italian libraries. The full-size Berenson and 'Grosvenor' collections and

the authoritative reproductions of the Reale Commissione Vinciana are available in far fewer libraries, and are supplemented in such places as the national and older university institutions by rarer reproductions going back to the eighteenth century and the engravings of Hollar. Drawings interspersed in Leonardo's MSS. are reproduced in the facsimile editions by Ravaisson-Mollien, Sabachnikoff, and Calvi, available in the larger libraries, and many are to be found also in the collections of Leonardo writings edited by Richter and by McCurdy. Originals commonly seen in this country are chiefly items from Windsor, and the few in the British and the Victoria and Albert Museums.

In examining any of these collections, some basis of classification will be required. For the purposes of the present enquiry I propose to devise a classification according to the nature of the feeling which the drawings convey. Some features of a possible reclassification by date will be quoted later, as serving better the solution of the problem than the propounding of it. The following readily distinguish themselves in my classification, and I consider that they include the types or moods most peculiar to Leonardo.

I. Drawings which depict an intense effort. Characteristically in these a mental concentration is expressed by a physical action in which animal or human anatomy is strained almost to breaking point. Here a strict naturalism is not overstepped but is deliberately exploited to convey an overwhelming sense of urgency; for instance the muscular detail is mechanically perfect, whether the anatomy is that of a horse and rider in the agony of mortal struggle or that of a composite creature with the wings or head of a dragon.

II. Drawings expressing the unselfconscious gracefulness of children and animals in their completely carefree moments. Characteristic are the remarkably large number of sketches of madonna with the child who is clutching or teasing or struggling with a cat or a lamb. The amused tolerance of the girlish mother, the earnestness of the baby, and the absurdity of the attitudes into which the group get themselves, convey a delicately irreverent humour which is quite foreign to the traditional sober representation of the holy family in Leonardo's age. Sketches of kittens tumbling over each other, various animals in the intimacies of their ablutions, etc., are other examples from Leonardo in this mood of engaging innocence.

III. Allied to the type I, are the drawings of cosmic disaster, but distinguished by more radical departure from living model. Their tiny humans express an extremity of despair as their cities are

PLATE 13. DISSECTED FOOT OF A MONSTER
Ink upon silver point drawing at Windsor

PLATE 14. FANTASTIC BETROTHAL
Silver point drawing at Windsor

PLATE 15. STUDY FOR THE LAST SUPPER
Red chalk and ink drawing at Windsor

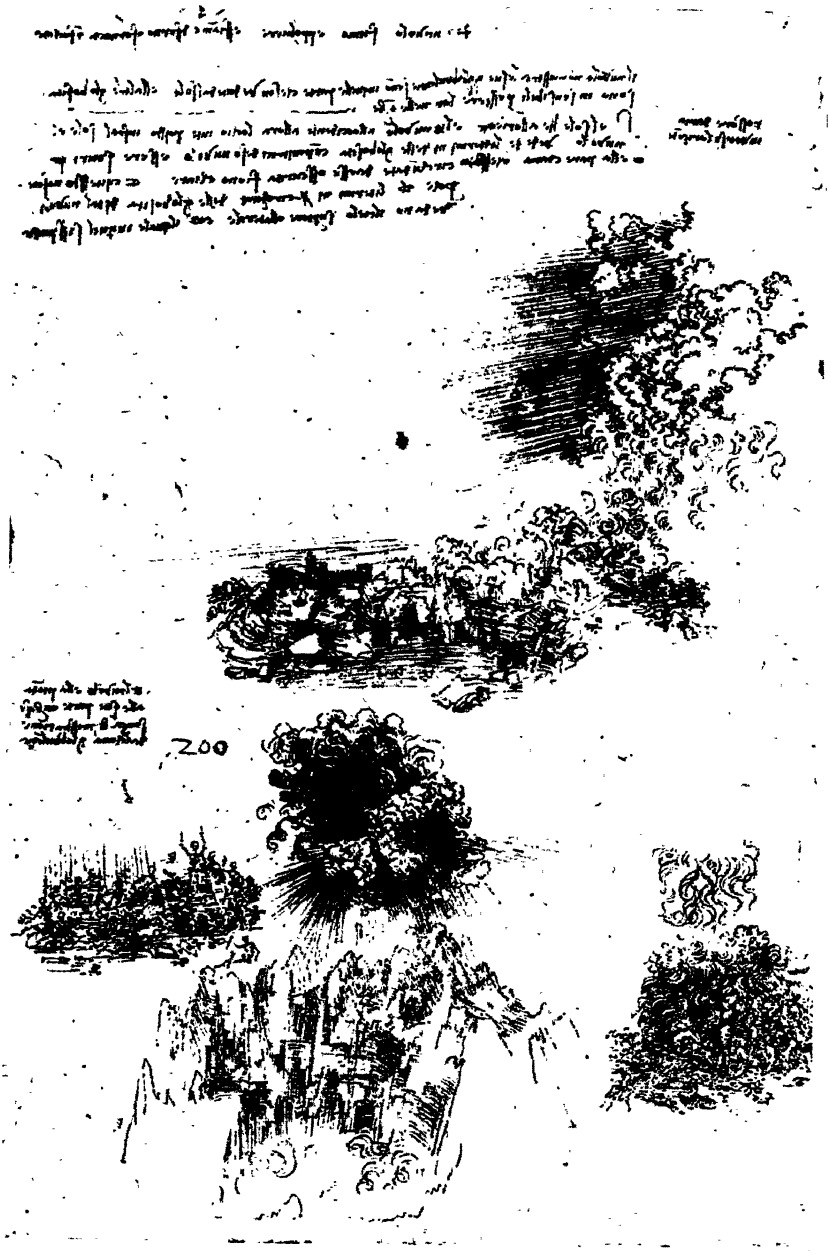


PLATE 16. CATASTROPHIC FANTASIES
Ink upon black chalk drawing at Windsor
Copyright H.M. The King

overwhelmed in flood or tornado or volcanic outbreak. These drawings curiously overlap many of his scientific diagrams, where the curvature of water waves seems to have preoccupied him almost to the point of obsession; the combination of emotional expression with science becomes very striking where the human agony is set against the careful hydraulics and meteorology of the storm.

IV. In contrast to the violence of I and III and yet more profound than the playfulness of type II, is the mood of unassailable serenity in some other drawings, particularly of women's faces. One or two of his few surviving paintings are famous for this, and there are drawings whose eyes look steadfastly into a world where they find nothing to shake their peace of mind and the unapproachable superiority to fate which they seem to have attained. This air of confident reliance on some secret knowledge is perhaps the most subtle and intangible attitude in Leonardo's art: hence although many imitators have attempted drawings which are superficially of this type of expression, none has succeeded in conveying the same profundity of character in such charm and simple dignity. Clark, in the Windsor catalogue, has commented upon the facility with which uncritical admirers have transferred their enthusiasm to these imitations, some books on Leonardo being almost entirely illustrated by spurious examples. It is a memorable experience to examine, as can now be done at many libraries, the various copied and imitated faces ascribed by Clark to followers of Leonardo, and to compare them with genuine examples even in reproduction. Under such scrutiny the vanity or petulance of faces by d'Oggiono or Salai lose entirely their spurious kinship with the supreme serenity of the Leonardo drawing, even when the features are at first sight of closely similar type.

V. At the other extreme are Leonardo's grotesques. Many of these represent hideous malformations in facial anatomy, and the expressions conveyed are sometimes of maniacal fury, sometimes of quiescent and pathetic resignation or even of complacent acquiescence in ugliness. The most terrifying have given rise to many copyings, dating from the sixteenth century and later, but these lose their horror as surely as second-hand versions of his serenity lose their spirituality. The famous 'Ugly Duchess', which Tenniel copied for 'Alice in Wonderland', comes from a Windsor example which is itself a copy whose original is lost. A lesson in catastrophic psychology is to compare the appalling head of a man, from Hamburg, with its counterpart at Windsor: the latter is possibly

by Melzi, Leonardo's own pupil, and resembles the original closely in every feature except the unforgettable eyes.

I shall consider later some points in which these drawings differ from types common to Renaissance contemporaries and predecessors, and from those expected along the lines of inherited Greek aesthetics. For the present I select them as index to the problem offered by Leonardo's drawings, so that while seeking the relation of his science to his art we may keep in mind the facts which it is necessary to correlate.

The Drawings as Representative

There would be little use in accepting these types of drawing as affording insight into Leonardo's remarkable personality, unless there were some right to assume that they are genuinely representative of him, and not a selection due to the accident of history. This assumption is often made without any accompanying justification. Clark's Windsor catalogue, however, and various introductions to the MSS., have now collected and assessed sufficient evidence from which the following conclusions may be drawn definitely enough for my present purpose.

Of about 600 Windsor drawings, the many spurious are copies or works of pupils, and thus are likely to be true in type even when not in style. The collection is the major remnant of the 779 found at Kensington Palace and first reported in 1778. Those missing comprise almost as great a number as the entire world collections of the larger drawings outside Windsor, and include some of the most violently grotesque, known from Hollar's engravings of 1645-51. It seems probable that the original nearly 800 formed the scrap-book obtained by the Earl of Arundel from Don Juan de Espina to whom Pompeo Leoni had sold it before 1610. Leoni, sculptor to the Spanish court, had compiled this book out of sheets purchased after 1570 from the son of Francesco Melzi. The latter was the pupil and testator of Leonardo himself, and in contrast to the succeeding generation had taken reasonable care of his master's legacy.

It is important to recognise what a considerable portion of the material in Leonardo's hands at his death is still available. Leoni's holding seems to have covered most of the MS. possession left by Leonardo, although the younger Melzi may have countenanced some previous individual depredations. But Leoni is known to have sold a great deal in Italy, in addition to the single compilation which went to Spain and of which the major part is now at

Windsor. The Italian portion included the very large collection given by Count Arconati to the Ambrosiana library of Milan in 1636, and the famous Codex Atlanticus still there contains much of Leonardo's scientific and philosophical work. In 1796 Napoleon took away all the Ambrosiana MSS. to Paris and only the Codex Atlanticus was ever restored; thus a large bulk of the illustrated MSS. belongs now to the Institut de France, including some which have wandered but have been returned through Lord Ashburnham.

The Codex Atlanticus and the MSS. of the Institut de France are the largest single collections outside Windsor, but are of a different character, their illustrations being in general small and incidental compared with the Windsor drawings. The latter are often large sheets of single subjects or smaller ones cut out from their manuscript context: a minority show the feature familiar in the French MSS., of note-book pages almost accidently entrapping fugitive marginal sketchings where madonnas, angels, animals and plants jostle with the gear wheels of engineering designs. The Turin MS. 'On the flight of birds' and the separate Windsor anatomical MSS. exhibit both these characters of intentional drawing and incidental note-illustration, while the Victoria and Albert note-books include more pages of the latter type. The much smaller collections of more formal drawings at Oxford, Chatsworth, the British Museum, Milan, Florence, Venice, and in Germany and France, are often of the character of the large Windsor drawings and reinforce the general impressions derived from the latter.

Hence although about 200 drawings once known to exist are missing, the great Windsor collection and the many smaller ones may be considered as representing not a single phase of Leonardo's genius but a reasonably comprehensive record. This impression is confirmed when their chronological distribution over his career is studied and found to be by no means restricted to any single period.

The Problem of the Naturalist's Note-book

A first step towards understanding the Leonardo of the drawings is to recognise that he drew not merely as a preliminary to deliberate composition, but as the instant reaction to things perceived. It may become necessary to add to 'material objects perceived' the states of mind of which he became aware by external observation and possibly also by introspection. The clue to the situation lies in Berenson's analysis of Florentine drawing, in

which Leonardo is exhibited as sensitive of perception but as possessing an abnormally low estimate of the power of words, and hence as relying upon a visual instead of a verbal notation as means of expression.

When this is recognised, my previous classification of the material into formal drawings and incidental illustrations appears to cover a common psychological basis, and much of Leonardo's art can be regarded as exhibiting the same habit of mind as his scientific notes: both become aspects of the recording of impressions by an observing naturalist. The two aspects occasionally interpenetrate. For instance, sheets of geometrical diagrams contain fragments also of human faces; there is a notorious instance of a tiny 'Leda' sketch between mathematical calculations, and an exquisite violet with leaves and flower occurs on a page devoted to geometry of architectural design.

It is this character which explains why so large a fraction of Leonardo's work remains to us in the form of drawings. The history of the MSS. and drawings, outlined in the previous section, makes it unlikely that mere accident of survival should provide them in hundreds or thousands of sheets compared with half a dozen paintings and a few doubtful sculptures. The numerical discrepancy is still more remarkable when we recollect that the more deliberate compositions were in constant demand by contemporaries and treasured by later collectors, while the loose sheets were less concernedly preserved.

From another aspect also the superabundance of drawings is unexpected unless we agree to incorporate them as part of the naturalist's note-book. Even his notoriously unsatisfied critical faculty does not nearly account for them all as preliminary studies for painting. For example, in the well-known sheets of horse studies, some might conceivably be exercises preliminary to a considered design such as preoccupied him in connection with the Sforza monument; but among them are most unmonumental but perfectly natural horses, in attitudes of distortion which may have been seen but upon which no one would choose to base a formal study. Similarly, in the series of madonna with child and cat, some may be trial attempts at a picture which we do not possess, but there are some in which baby or cat or even mother are in actions or attitudes quite unsuited for formal production. The habit of wordlessly transferring observation or feeling on to paper seems to have overwhelmed the use of drawing as technical exercise.

But when we accept the drawings and the MSS. as inseparable aspects of a single habit of scientific observation and recording, we at once face the most intriguing and elusive problem of Leonardo's personality. Not only are there too many sketches for the painter's self-discipline alone, but the prevalence of fantastic transition into non-existent monstrous types is too insistent to allow the whole collection to be labelled unquestioningly as 'Observation'. When a sequence of mammalian specimens suddenly develops a reptilian tail we begin to admit that this naturalist's note-book is not confined to observations of any external world. The monsters in the margins of the engineering designs raise the same question as do the more infernal (and celestial) types which are found in my classification of the larger drawings. Was Leonardo ALWAYS a scientific observer, and if so what was he sometimes recording? Were mental states as consistently seized upon as was his visual environment, and did he sometimes unconsciously or even deliberately find a gross parody of external nature more appropriate than nature itself for expressing the facts of psychological study? Or was he just ridding himself of the consequences of personal exaltation and despair?

There is a feature in these drawings which is apt to escape notice, but which suggests that they are not mere arbitrary nonsense compounded accidentally out of fragments of an external world; it reinforces any conviction that even in the most fantastic we do not evade the pattern of Leonardo's mind. This feature is the recurrence of closely similar expressions in creatures of superficially different character. Scrutiny at Windsor reveals various examples. We see, for instance, lions' jaws and human mouths in identical muscular tension expressive of the same frenzied emotion. In many scattered sketches the eyes of a dog, of a horse, of a man, of a monster, exactly reproduce certain expressions which only the self-conscious human mind could become capable of exhibiting. In purely human physiognomy, the young man of the grotesque Bridal Pair at Windsor has an expression—whatever be the secret of its horror—identical with that of the sketch for Saint James.

Even the trees and cloud forms are twisted into shapes disturbingly suggestive of a human intensity in emotions similar to those expressed in some of his faces. Thus the ancient tradition of Nature the symbol seems not to have escaped even this most 'objective' of artists, and the tradition may well have reached Leonardo through Vitruvius, since Heydenreich has traced some parallels between human morbid anatomy and Leonardo's architectural forms. The

underlying conception is not unrelated to the well-known medieval attribution of the properties of an organism to geographical and other inorganic entities, which reappears finally in the medical terminology of Paracelsus and others of the fifteenth and sixteenth centuries.

All these are examples of human or non-human or even inanimate expressiveness in Leonardo drawings, which demand that we accept them as symbolic of a self rather than as representative of any external situation. They irresistibly point to an origin in some mood within the artist rather than in any impression solely from outside.

Overlapping such symbolic uses of the fantastic there are the commoner accounts of the more peculiar of Leonardo's drawings. Many scientists allow their minds to develop in watertight compartments, and it is possible that Leonardo intermittently relaxed the rôle of the scientific observer who records only the world that we possess in common. The unnatural drawings have therefore been sometimes ascribed to the recreation of a poetic imagination, the satire of a politician, or the fervour of a religious propagandist. But mere impishness becomes an incomplete explanation for anyone who penetrates beyond the mild copies to which the more appalling grotesques are often mercifully reduced. For instance the early engravings by Hollar are apt to convey a vacant benignity of expression until the terrible intensity seen in an original deprives the situation of any playfulness.

Nevertheless all these elements, and others, may play some part in Leonardo's art, and it is unlikely that any age will succeed in correctly distributing the emphasis among them. My particular contribution involves submitting the following study of the scientific attitude which he seems to have allowed to pervade his whole relationship to experience: I believe that it may supply a new clue, enabling us to approach more nearly than hitherto to the probable balance between these several elements in that unique variety of drawings.

Chapter 17

The Nature and Evolution of Leonardo's Scientific Mind

The Types of his Achievements

There are now many treatises and monographs expounding the detail of Leonardo's scientific researches, based upon modern editing of the countless fragments in the Codex Atlanticus, the MSS. of the Institut de France, the Victoria and Albert MSS., the Windsor anatomical MSS., etc. I am not pretending here to add to these expositions. For the purpose of the present problem their contents are only relevant as far as they contribute to building an estimate of Leonardo's general state of mind and attitude to experience. We need at the beginning to know to what extent he was permeated by the scientific habit. We shall next need to understand how that habit evolved in him and how it affected his art. For these psychological aspects of Leonardo the scientist, Séailles is perhaps the most valuable of the assessors of his investigations, but I will abstract as follows from many authors sufficient for the peculiar bias of the Leonardo mind to emerge.

He was not primarily a mathematician; the note-books reveal large numbers of geometrical diagrams, but fewer calculations or solutions of equations, and almost all of both these were introduced as subsidiary to mechanical problems. Many Renaissance artists were keenly interested in geometry for the sake of perspective, and Leonardo not outstandingly more so than others. Chemistry and chemical metallurgy again interested him mainly as a means for effecting the preparation of substances needed in other sciences and arts. The mechanical and physical sciences, on the other hand, he studied for their own sake. From one of his note-books: 'Mechanics is the paradise of the mathematical sciences because in it we come to the fruits of mathematics.' But he was not a theorist, and when I say that he anticipated the principle of inertia of Galileo and Newton I mean that his notes reveal its unconscious use in attacking particular problems, rather than that he possessed any of the generalising power of a Newton. The notion of equality

between action and reaction arises similarly in his notes. Mechanical problems in which quantitative exactitude plays the dominant role most absorbed him, and it was these which developed his love of recording phenomena and of reproducing their underlying principles in apparatus of precision. In the designing of graphical methods for kinematics, the resolving and (not quite correctly) compounding of forces in statics, the use of work as product of force and displacement, the applications of inclined plane motion, of pulleys and other multiplying gear, the use of impulsive forces, the study of centre of gravity in all kinds of geometrical structures, the transmission of power, the reactions of load and supports, and the strength of complex framework, together with friction and the entire sciences of hydrostatics and hydraulics, we see Leonardo as the pioneer of minute care in observation, checked by ingenious control of experimental test. His researches in aerodynamics especially show his power of natural observation in shrewd analysis of the details of bird flight, and here his unrivalled anatomical and physiological knowledge was combined with mechanics in exploring the possibility of human control over the same forces in the same medium. The lack of an internal combustion engine prevented his aeroplanes from flying.

Outside the physical sciences the same development of acute observation gave him the greatest pre-modern understanding in anatomy and physiology, notably in embryology where precision is particularly rewarded by insight into the working of cause and effect in all branches of biology. It is typical of the same strength and weakness already seen in his physics that exactitude of detail is of more interest to him than generalisation; as with the principle of inertia, his anticipation of understanding the blood circulation is an incident rather than a deliberate conclusion.

In palaeontology and physical geography and meteorology he is again the supreme observer of his time, and he seems the first to have envisaged the correct explanation of stratigraphy and fossil life in terms of successive alterations in land and sea level. It is of interest to note the COMPARATIVE scarcity of astronomy in his MSS., in which connection we remember that he appreciated geometry mainly for the solution of those problems on which he could himself experiment.

In estimating the wide range of his insight into nature and the control of nature, we may recollect that among the later developments anticipated or foreshadowed in his note-books were air transport, submarine transport, the use of steam for motive power

(not in vehicles, curiously enough), principles of illumination to be inferred from lunar observation, phyllotaxis as clue to plant biology, the dating of trees by age rings, together with many technological devices such as the camera obscura and the taximeter, as well as the more fundamental notions which I listed before. A single note even suggests that he may have realised the falsity of geocentric cosmology.

The mind of Leonardo cannot be correctly appreciated without tracing the part played by predecessors in its formation, to which enquiry I proceed later; but the above classification suffices to lay down the remarkable universality of his scientific interests. This universality includes a definite bias towards subjects in which natural phenomena could be put through the sequence of observation, recording, and human control, and a bias away from subjects where individual study might be dominated by *a priori* principle or prejudice. Subject to this bias, the antithesis of most medieval and even Renaissance science, he must be considered as accepting every part of the external world as material for investigation.

His Method, with Greek, Oriental, and European Comparisons

If Leonardo has thus to be accepted as an encyclopedist, it must be remembered that for pre-modern science a superficial acquaintance with a large number of subjects simultaneously was not unusual. Narrow specialisation was not so necessary at that time as it has become for us in the complexity of modern research. Leonardo's status is not, however, merely that he was an original thinker when other encyclopedists were only collectors; we understand him more nearly when we pursue the choice by which he selected his favourite topics, and allow that choice to illustrate his scientific method. He then begins to stand out even more radically from the mass of contemporaries and predecessors.

We see signs of his attitude towards scientific methodology when we recollect his lack of enthusiasm for subjects dominated by broad hypotheses; he was well aware of the tendency for hypothesis to degenerate into the frozen prejudice which was the bane of medieval thought. It is this attitude which most decisively makes Leonardo an ultra-modern among a society still medieval in much of its intellectual outlook. We find in him the new insistence upon the need to experiment oneself if nature is to be understood, and upon the need to be entirely free from *a priori* opinion or ethical bias as to the result of experiment.

He refers to himself as *discipolo della sperienza* and writes: 'Anyone who in discussion relies upon authority uses not his understanding but his memory.' Again, 'Many will think that they may reasonably blame me by alleging that my proofs are opposed to the authority of certain men held in the highest reverence by their inexperienced (i.e. not based on experiment) judgments, not considering that my works are the issue of pure and simple experience, which is the one true mistress.' Again, 'Before making this case a general rule, test it by experiment two or three times, and see if the experience produces the same effect.' 'Without experience there can be no certainty.' 'Experiment never deceives, it is only our judgment which deceives us.'

His researches in aerodynamics contain examples particularly suited to illustrating this character of his method. 'A bird is an instrument working according to mathematical law, which instrument it is within the capacity of man to reproduce with all its movements, but not with a corresponding degree of strength.' 'In order to give the true science of the movement of birds in the air, it is necessary to give first the science of the winds, which we shall prove by means of the movement of the water; this science is in itself obvious to the senses, it will serve as a ladder to arrive at the knowledge of winged creatures in the air and the wind.' 'Of the bird's movement—in order to speak of this subject it is necessary that in the first book you treat of the nature of the resistance of the air; in the second of the anatomy of the bird and of its feathers; in the third of the action of these feathers in various of its movements; in the fourth the strength of the wings and tail without beating of the wings, with the help of the wind to serve as guide in various movements.' 'Before writing about winged creatures, make a book about how inanimate things descend through the air without wind and another about their descent with the wind.' Whence we find Leonardo considering the descent of a board of uniform thickness placed first horizontally and then obliquely in the air.

Such procedure in research may be contrasted with general trends throughout the ten centuries between the Greek and modern eras. There had been many scattered solitaries in European science, but most of those who had been actual experimenters had chosen chemistry with a mystical flavour which expressed itself in alchemy. This flavour had forced the sciences to depend essentially on *a priori* principle or prejudice, and rendered them unlikely to flourish if Leonardo's empiricism and impartial analysis

were to be adopted as their method. From all such medievalism Leonardo is separated as a conscientious investigator who lets the facts determine his course, and who regards with misgiving any conclusions based upon authority or uncritical tradition. A note in one of his South Kensington MSS., 'O speculators on perpetual motion, go and be the companions of the searchers after gold,' conveys his opinion of pseudo-science.

Subsequent history has shown that this attitude of Leonardo is essential to the method which characterises the modern physical sciences, where observation, prediction, and check by controlled experiment all depend for success upon their reduction to quantitative treatment. In thus aiming at mathematical form, Leonardo was fundamentally a physicist even when engaged in biology, a fact frequently obvious in his ingenious adaptation of animal muscular systems to power production. In this sense he was not by choice of subject matter more preoccupied with physical than with biological sciences, but by his choice of method, which was always that of mechanics.

Again we have to regard carefully a contrast, not now with European but with Oriental predecessors. When I proceed to trace the channels through which Leonardo was influenced, I shall attribute much responsibility to the Moslem scientific world, and it seems certain that although the influence was indirect his science could never have developed if the Arabs and Persians had not studied Greek. But it is equally important to realise that mathematics was a collection of convenient devices to Leonardo rather than an end in itself, and that in this and his emphasis on experiment he stands in sharp contrast to the great line of scientists of Bagdad, Cairo, and Moorish Spain. Astronomy was the foremost of their physical sciences, as it was the least important for Leonardo, since geometry was their cherished goal and not the mere repository of experimental facts which it was for Leonardo. Many Moslems were better geometers than Leonardo, but very few of them approached his ability in experimenting and his fervour in pursuing experiment as the royal road to reality.

If Leonardo's method is closer to that of the modern physical scientist than to either European or Oriental history, it is further back that we have to look to find its counterpart. He seems to have worked himself into a more intimate union with the essential spirit of Greek science than was possible to the temperament of other Renaissance scholars who formally utilised its results. By Greek science I mean especially the post-classical developments of the

Alexandrian age: Leonardo's note-books reveal a significant choice among the translated works which diffused to him through the Oriental and European channels which I analyse later. Thus it was not primarily the great systematiser and teacher of medieval Europe, Aristotle, but the later Hellenistic masters, who seem to have influenced him most. Among the latter Archimedes stands out as his nearest kinsman in scientific method. It is perhaps significant that another Greek, Apollonius, was the more brilliant formal mathematician, but although Apollonius was a primary source of inspiration to the Moslems his effect upon Leonardo was far less than that of Archimedes. Actually the statics and hydromechanics on which Leonardo based his most multifarious applications are the two branches of physical science in which Archimedes was furthest ahead of the ancient world. It is not only in knowledge but in means of attaining knowledge that Archimedes is the most intimate predecessor of Leonardo and the really modern scientific mind of antiquity. Like Leonardo, he was not attracted by the more popular mirages of astrology, alchemy, or even cosmology, but spent himself with devotion upon subjects susceptible of quantitative investigation. He has probably more right than any other individual to be called the founder of the exact sciences, and although there were in intervening ages a few of similar sympathies among the many Persian and Arab scientists, there were far fewer among Europeans.

I suggest that the link from Archimedes, through intermediaries who often ignored Archimedean methods, provides an essential clue to Leonardo's final outlook.

Leonardo also shows affinities with Heron, Euclid, Ptolemy, and Pappus, and the Roman Vitruvius, among physical scientists, and with Pliny, Galen, Hippocrates, Celsus, and other biologists. In assessing his method and temperament it is to be noticed that all of these are distinguished from the more classical writers by their empirical rather than metaphysical interests.

Was Leonardo a Psychologist?

The attempt at assessing Leonardo's scientific range and method now requires an appendix, since most writers have confined their attention to him as physical and biological investigator. It would make him still more striking an anticipator of the present day if we accounted him also a psychological investigator, and it becomes interesting to enquire whether there is any evidence that he regarded mental phenomena with the objective curiosity in which

he inspected the entire external world. The question might well have been raised by historians of science, but it becomes inescapable as soon as his science is judged relevant to the understanding of his art.

Let us revert to the well-known phrase in his treatise on painting, that the duty of the artist is to depict 'man and the intention of his soul . . . the latter is difficult.' I suggest that this is worth more regard than has been given to it hitherto, and that future biographers may even have to decide whether they suppose his own soul was not exempt from being thus depicted consciously as well as unconsciously. It may be that he included mental states among a universal collection of scientific objects, and so observed things which were no part of anyone's external world: if these were appropriately to be expressed by drawing creatures and expressions which were also no part of anyone's external world, the most fantastic drawings might no longer seem at variance with the universality of his scientific attitude.

It is not difficult to show that there are in his MSS. many indications that he applied his observational and even experimental methods to mental phenomena, notably by introspection to his own. For instance he anticipated modern methods of the semi-conscious implanting of suggestion. He found out how to utilise the moments of maximum diffusion of attention, 'on studying in the dark' before sleep and after waking. He understood and commented on the sublimation-value of intellectual labour. Much of his treatise on painting betrays shrewd self-analysis in classifying the best sequence for developing a learner's abilities. Some of the ethical passages in his notes are more strictly items of descriptive psychology, and his criticisms of current ecclesiastical abuses are often simple statements of fact, merely recording with all his usual objectivity the state of mind which he infers from the behaviour of church dignitaries. We even hear from outsiders of some crude experimental psychology, such as his attempts to select strangers of striking features to tell them jokes and so to study their facial contortions in laughing. Again we recollect that he controlled by music the expressions of Mona Lisa while painting her portrait.

If we accept such a keen awareness of mental states, including his own, it constitutes a rarely recognised counterpart to his habit of observing all physical and biological phenomena. Can we expect that his urge to record all his findings in drawing should fail his psychology when it served so well his physics and biology? Will an

answer to this question make the serene and mysterious smile of his madonnas, the maniac shriek of his deformed monstrosities, his battles of dragons, his earthquakes and volcanic disasters, all to be conscious or unconscious recordings of a state of mind?

It has been necessary first to isolate Leonardo's net achievement from any considerations of its mode of growth, in order to see its contrast against that of other individuals and movements in scientific history; but to obtain light on his personality and character, its growth in response to external influences must next be investigated. Although I deal more particularly with the scientific aspects, concern with the effect upon his art makes it necessary to compare the environments scientific and artistic in a way which may have escaped those commentators who are interested in the science or the art alone.

Comparisons between his Teachers and Pupils in Art and Science

The unique nature of Leonardo's art is inadequately served by the common record, that he was the apprentice of Verrocchio in fifteenth-century Florence but the master of the Milanese painters of the sixteenth century. It is probable that one or two of the doubtful earlier paintings and the still more doubtful sculptures were collaborated or pupil-work with Verrocchio, and it is likely that this master introduced him to classical art by utilising him for the sorting of relics in the possession of the Medici. It is also certain that his sojourns at Milan greatly influenced among others Andrea Solario, Sodoma, and Luini; in the facial types of the latter painter some of Leonardo's mysterious serenity seems occasionally to be caught. His fellow pupil in Verrocchio's atelier, Lorenzo di Credi, is probably responsible for some of the earlier work which is attributed to Leonardo, and Milanese paintings by Ambrogio Preda and Boltraffio are sometimes difficult to distinguish from his. The same can be said of many drawings by Cesare da Sesto, Melzi, Boltraffio, Preda, and even works by Marco d'Oggiono and Bernadino de' Conti. Berenson's classic study of Florentine drawing traces a sequence in draughtsmanship from Antonio Pollaiuolo through Verrocchio to Lorenzo di Credi and to Leonardo, finally influencing through him Boltraffio, Sodoma, Solario, Melzi, and Salai, the more immediate personal pupils. But no one of these, either teachers, fellow learners, or pupils, possessed the faculty with which I am concerned in this essay, the constant use of draughtsmanship not merely as an exercise preliminary to painting or sculpture but as an almost instinctive recording of impressions

from observation. In this, apart from any technical skill wherein his pre-eminence is expounded to us by the art critics, lies his distinction from the contemporaries in Florence and Milan and elsewhere.

It is therefore in this sense that one of his greatest artistic individualities is due to the habit developed in his researches. This habit arose from being not only a scientist among artists but the constantly and persistently investigating scientist; for of course he was not the only painter in fifteenth-century Italy with more or less scientific leanings. The anatomy of the Pollaiuoli and Luca Signorelli, the zoology of Pisanello, and the reasoned naturalism and balance in Verrocchio, differ in intensity and depth rather than in essence from the work of Leonardo, while perspective geometry was studied widely among contemporary artists, such as Uccello and Piero della Francesca. But since I have enumerated some of the subjects of his investigations, and recollect Berenson's analysis of his medium of expression, quoted in an earlier chapter, one may recognise that in no one but Leonardo is found this habit of using a draughtsman's technique as a constant recording device over so wide a range of his experience.

In science even more than in art it might be said that he accepted technique from teachers but utilised it in a spirit which went beyond them in its universality of application and modernity of intellectual freedom. But in science he had fewer disciples than in art. Artistic technique proved easier to communicate, or his generation readier to desire the communication, than in the case of scientific technique. Compared with the considerable array of Milanese painters whose best work is an imitation of his style if not of his spirit, the scientific world took little notice of him after his death until modern times, when the discovery of his anticipations of later work became startling. Actually, Venturi in 1796 was the first to draw public attention to his scientific MSS. Among contemporaries he was not averse from discussing his investigations with friends, of whom Luca Pacioli the pure mathematician was possibly the closest. But this choice is itself an indication of the scarcity of kindred spirits, as we have seen that mathematics was essentially a detail in means, not an end, to Leonardo, whereas to Luca Pacioli it was the summit upon which the human reaches the divine. The association with Luca Pacioli is one of the rare instances of collaboration known in Leonardo's scientific life: after the former's publication of the first arithmetical and algebraic text-book to be printed (1494), he was assisted by Leonardo in

appropriate aspects of further work for *De divina Proportione*, and when political changes drove Leonardo from Milan in 1499 Luca Pacioli travelled with him. During the same early Milanese period of Leonardo's life there were others available for scientific discussion in addition to Luca Pacioli; from the studies of Séailles and of Hart it is possible to enumerate nearly a dozen names, but only the Cardan family seem likely to have derived much from him. The circle of fellow scientific investigators seems to have left to subsequent generations far less of corporate discipleship than the group sometimes misleadingly called his 'school' of Milanese painting. In the isolated individual instance which may be important, Jerome Cardan, mathematician of the next succeeding generation, knew something of Leonardo's experiments through his father Fazio Cardan. The latter was a friend of Leonardo, and of the pupil-companion of his later years, Francesco Melzi, who inherited the MSS. In Leonardo's later Milanese period he became very appreciative of the work of Marc Antonio della Torre, the young anatomist of Padua, Venice, and Pavia, and their association may be accounted as the only important instance of scientific collaboration following the earlier friendship with Luca Pacioli.

But although contemporaries learnt less science than art from him, he was perhaps more earnest in pursuing earlier workers in science than in art. From the earliest beginnings of the Renaissance until his own time, a large number of individuals concerned with particular branches of science had been turning the translated knowledge of the Graeco-Moslem world into an embryonic European body of learning. Just before Leonardo's time and either read or met during his youth, Nicholas of Cusa, Konrad Kyeser, Leon Battista Alberti, and Paolo Toscanelli, were probably the most important. It seems likely that his introduction to Greek science was through Giovanni Agiropulo, who taught in Florence during the first twenty years of Leonardo's life. It was the age in which Bessarion and his MSS. were stimulating Purbach and Regiomontanus to take the first steps towards a European trigonometry and astronomy. More distant influences were Albertus Magnus, Bacon, Leonardo of Pisa, and Jordanus Nemorarius, his thirteenth-century predecessors. But in no list of names, however comprehensive, are all Leonardo's subjects of research to be collected.

Since Leonardo utilised these writers not only for their own originality but for their transmission of a Greek science even more vital to him, his mental evolution next requires us to investigate

some of the lesser-known aspects of the diffusion of Greek knowledge to the Renaissance. If Leonardo had Greek affinities, what chances were there of any personal acquaintance with the Alexandrian works in edited or unedited versions? In a particular instance, it is of importance to realise the kind of activity required of him to reach contact with Archimedes, whom I classify among the Alexandrians although most of his later life was spent at Syracuse.

Leonardo as Inheritor of Graeco-Moslem Science

We arrive at the importance of the Oriental percolation of Greek science to Leonardo's Italy, by contrasting his actual finished method with that of European and Moslem and finding it more akin to the Alexandrian, and by recognising that much of the function of his masters was thus transmission rather than originality. What did the Arabs and Persians and Byzantines do to Greek science, that Leonardo could acquire from them its form while becoming truer to the spirit of the original than were these editors and their transmitters?

The most important channel conveying Alexandrian influence to Leonardo was opened through the collecting and editing of Greek scientific MSS. by the Arab translators at Bagdad in the ninth and tenth centuries. It is nowadays recognised that translation from Syriac and Persian, as well as direct from Greek, played a part in preserving the Greek spirit at Bagdad, though doubtless complicating the accuracy of detail. This accumulation was followed by a diffusion from Bagdad through Moslem Egypt and Morocco to Spain. From the eleventh to the thirteenth centuries the great libraries of Cordova and Seville and Toledo were the centres to which European pioneers resorted for retranslating this Greek from its Arabic versions and commentaries into Latin. The most prolific of the translators was Gerard of Cremona in the twelfth century; the work of Haskins reveals many others including Adelard of Bath, Plato of Tivoli, Robert of Chester, Hermann of Carinthia, Rudolf of Bruges, John of Seville, Hugh of Santalla, Abraham ben Ezra, in Spain and in centres deriving from Spain. Further translation was done in the thirteenth century by Alfred the English, Michael Scot, Hermann the German, and others. Some, such as John of Seville and Gerard himself, were heads of translating institutions: for instance Sarton's list of eighty-seven works under the name of Gerard obviously implies co-operative production. The Greek scientific authors reaching Europe by this

medium included Autolycus, Euclid, Archimedes, Apollonius, Hypsicles, Theodosius, Menelaus, Ptolemy, Diocles, among mathematicians and physicists. Among Moslem commentators also translated by Gerard were the Benu Musa, Al Kwarizmi, Al Farghani, Ahmed ibn Yusuf, Al Nairizi, and Al Zarqali, in the physical sciences, and Al Kindi, Al Razi, Ibn Sina, etc., in the biological sciences.

The short renaissance at Byzantium almost contemporary with that at Bagdad led to a second and smaller infiltration of Greek scientific MSS., which diffused more directly to Italy through Moslem and Norman Sicily, a migration many of whose remarkable aspects are also now available from Professor Haskins' studies in medieval science. At the beginning of Leonardo's time the capture of Constantinople by the Turks liberated a further flood of MSS. into European exile.

Through these Spanish and Byzantine channels the teachers and contemporaries of Leonardo were in a position to develop something of the Hellenistic outlook. A single instance illustrates the occasional duplicating of the one source by the other: the MS. from which originated the first Latin version of Ptolemy's Almagest was a Greek codex brought from Constantinople to Sicily about 1160, whereas Gerard of Cremona produced a quite independent Latin version in 1175 from Spain, where its use had been far more familiar and commentaries were more widely discussed than in Byzantium or even Alexandria. It is possible that the Data and Optica of Euclid, and the Catoptrica sometimes attributed to Euclid but more probably by Theon, together with the Pneumatica of Heron, may all have reached Europe through Sicily independently of later Arabic editions; but it is doubtful whether without the example of the earlier Arabs they would have excited so much interest or passed through Sicily at all. The case of Euclid's 'Elements' further illustrates the duplicating of sources of Alexandrian science; Heath has traced their descent into Europe, beginning with the earliest translations at Bagdad. The first Latin version of the Renaissance of which we have definite knowledge was by Adelard of Bath, about 1120, and was certainly from the Arabic; the next was probably that of Gerard of Cremona, who translated also the commentary on the Elements by Al Nairizi. The third was by John Campanus about 1270, also from Arabic. The last of these was used in the first printed edition at Venice in 1482 in Leonardo's own time. At least two other printings appeared before Byzantine MSS. led to alternative

editions in 1505, etc., preceding the first authoritative edition of 1533 subsequent to the death of Leonardo. Among other writers important to Leonardo was Pappus the encyclopedic collector of Greek science: some of his mathematics has only now survived in Arabic. Again Heron, who next to Archimedes was perhaps the most Leonardesque of the Greeks, was translated by Ibn Luqa in the early Bagdad era.

The relative responsibilities of the Byzantine and the Moorish sources of Greek influence upon Leonardo differ somewhat from those commonly accepted for other scientists of the European Renaissance. The differences are instructive in appreciating the individuality of his mind. In particular we may contrast the descent of Aristotelian and Alexandrian traditions. Aristotle, whose logic had long been a buttress of medieval theology, became known to the Renaissance as a systematic biologist and as a metaphysician through both Arabic and Byzantine channels. But the Moslem editors wrapped the philosophical portions in such complex speculation, as cloudy as the earliest Aristotelianism of the European Middle Ages, that most of the scholars of the Renaissance found in the purer MSS. arriving from Constantinople a new and precious thing. Leonardo, however, was never a genuine Aristotelian, being as unsystematic as most pioneer experimenters, and not at all metaphysical in tastes: so that the checking of philosophical texts from Byzantium meant less to him than to many contemporaries, and it is even possible that the association of Aristotle's works with ecclesiastical subtlety detracted from their use to him as source of biological information. On the other hand the authors of greater interest to Leonardo were less liable to metaphysical obscuration when passing through the hands of Moslem editors, so that again the advantages of Byzantine over Moorish MSS. tended to be lost on Leonardo.

I have previously pointed out some contrasts between these more metaphysical and also more mathematical Moslems and the experimental Leonardo, and it becomes important to recognise the precise nature of the formers' additions to Greek science if we are to assess correctly the rebirth in Leonardo of a more genuinely Hellenistic spirit. The scientists of Bagdad, Egypt, and Moslem Spain were codifiers and elaborators of detail in most sciences, especially astronomy, and also were genuine inventors of new trigonometry and algebra. They were also philosophers in the sense of metaphysicians and logicians. But this means that they excelled in developing the Greek sciences in just those directions

which were of comparatively minor interest to Leonardo. It is only when their astronomical devices reached engineering proportions, or when a rare experimental physicist such as Al Haitham appears among them, that they could have offered to Leonardo more than the unconscious transmission of a divine simplicity that had characterised the Greeks and been lost meanwhile. We consider therefore that while the High Renaissance gained from new Byzantine sources much that the Moorish genius had obscured, on the other hand the Alexandrian physicists, to whom the Moslems had added mathematics rather than metaphysics, came to the earlier Europe with Spanish commentaries more stimulating than bare Greek MSS. But these commentaries happened to be most highly developed in qualities too formal for Leonardo's taste. His most outstanding individuality was to see beyond those accretions and their effect upon his teachers, and to realise the original simplicity and honesty of the Alexandrian spirit, and thus his greatest gain over other readers of Graeco-Moslem science was his virtual monopoly of the power to construct for himself a better superstructure upon an almost purely Greek foundation.

For this reason it is the earlier Moslems who served Leonardo the best, and the later elaborations of Greek science in Spanish, Egyptian, Arab, and Persian hands played only a minor part in his own development. It scarcely mattered that the greatest scientific institutions of the thirteenth- and fifteenth-century Persians, at Maragha and Samarkand, remained almost unknown to Europe until long after Leonardo's time. The gift of the Moslem culture which was most essential to him, the transmission of Greek methods on which he could himself build afresh, had already been fairly completed in the twelfth century and he received the major portion of it at second hand from Europeans who long before his time had been readers of Arabic-Latin.

My conclusion, that Leonardo gained little which was not Hellenistic from Oriental science, is a general interpretation from his MSS., and not to be regarded as exclusive of all exceptions; but when for example we find him borrowing from Cardan his copy of a work of Al Kindi, we must recall that this great Arab scientist had based his most characteristic expositions upon Ptolemy, Euclid, and Heron. When we admit how large a portion of Renaissance biology was Moslem-inspired, we should do well also to recollect that, in company with young della Torre, Leonardo was highly critical of Moslem anatomical methods.

His efforts to make use of the Greek transmission exhibit his

character most vividly when we realise that his approach to Alexandrian science was not a mere passive yielding to an environment. I have mentioned Archimedes as Leonardo's most intimate intellectual ancestor, and I proceed to utilise the researches of Heiberg, Heath, Sarton, and others in reconstructing a little of the circumstances under which Archimedean texts would have to be sought. Somewhat similar adventurous histories can be written of the course by which various Greek scientists reached the immediate environment of Leonardo, and we must bear in mind as a background to his note-books the facilities he had for obtaining access to such authors.

The Pursuit of Archimedes

We owe to Séailles the recognition of the profound likeness between Leonardo and Archimedes, but I do not necessarily wish to maintain the French scholar's suggestion that Archimedes was the basis of all modern science between Leonardo and Galileo: Archimedes never reached the almost Biblical authority which Aristotle had exercised over the medieval mind. This was not only because authoritarianism, even Archimedean, would be foreign to the modernist mind, but also because of a relative scarcity of texts.

Leonardo's first realisation of Archimedes was probably through one of the Italian predecessors whom I have named already, who had read perhaps the Latin of Gerard of Cremona, itself from the Arabic of Thabit's Archimedes. Thabit ibn Qurra, translating in Bagdad from Greek to Syriac and from Syriac to Arabic with MSS. obtained by the Caliph's agents in Byzantium, was a link without whom the European discovery of science might have been very different.

But after Leonardo had utilised second-hand information on Archimedes from such as Leonardo of Pisa and Jordanus Nemorarius, we find his notes giving hints of pursuit of the actual writings. It is salutary for modern scientific researchers, comfortable in their bibliographical facilities, to realise Leonardo's conditions of any such pursuit. There were a few great libraries in fifteenth-century Italy, the private repositories of collectors associated with the Medici and other great families. An important example was the library of the Duc d'Urbino. There was also the papal library. Although printing became widespread during Leonardo's time, it is recorded that owners of some of these libraries prided themselves on still employing manuscript copyists, with a feeling that the new process of reproduction was undignified and almost improper. We

discover several points of contact at which Leonardo succeeded in making use of these libraries by the accident of circumstance. He seems to have profited by his presence in Urbino shortly after his employer Cesare Borgia captured the town, as we hear of him recognising from there an Archimedean MS. Later, a temporary return to Florence seems to have been the means of laying his hand on further Archimedean documents. On these in particular the British Museum MS. of Leonardo's statics is based. In fact all his hydrostatics and statics, in some ways the most striking developments of his scientific genius, depended upon Archimedes through Arabic and through earlier Europeans, and finally through actual access to Latin versions thus met by the chance of political accident. Occasionally, suggestive details of his cultivation of Archimedes are recorded in phrases which beg someone to 'borrow the Archimedes' of some library-possessing ecclesiastic.

What actual MSS. were they, which formed the prize of these spasmodic and unreliable encounters?

There still exist in Florence, Venice, and Paris, four Greek MSS. which were used in the earliest printed edition of Archimedes, of 1544, and were copied about 1450, 1490 and 1540, the last date being after Leonardo's death. They all derive from a MS. originally belonging to Leon of Constantinople and now lost, containing many of the most important works. This MS. had been copied during the ninth or tenth century at Byzantium from versions by Isidorus and Eutocius of the sixth century, the copying being a typical incident in a renaissance which seems to have followed remarkably the great era of Bagdad. It is possible that the demand for Greek MSS. at Bagdad may have contributed to stimulating this vigorous revival of editorship at Byzantium, and Leon's MS. was perhaps not unlike those which began the Archimedean collections of the Moslems and thence descended to Europe through Spain. In the twelfth century Leon's MS. passed through the Norman court at Palermo, and was in the papal library after 1266, and between then and 1550 it belonged to several successive owners. In 1269 a Latin translation of most of this MS. was made by the Flemish William de Moerbeke, who had access also to portions omitted in Leon's MS. In Leonardo's time, parallel to this Latin version there seem to have been two others known, one by Jacopo Cassiani of about 1450 and one revised by Regiomontanus about 1468. All other Latin copies, including portions not otherwise extant, were derived from Arabic through the channels which I have mentioned as the major source of Greek

for European consumption. In particular, Al Mahani, Thabit ibn Qurra, Yusuf al Khuri, and Ishaq ibn Hunain were among the earliest scientists of Bagdad known to have produced Syriac and Arabic versions of works by Archimedes. These passed in turn to Spain and the translators of the twelfth century, and ultimately became available for importation to Italy.

The extreme rarity of such occasional MSS. in Leonardo's Italy shows us startlingly the poverty of his bibliographical facilities: it leaves no possibility of regarding his careful discipleship of Archimedes as the whim of a dilettante straying from art into science when encouraged by the fashion of the time, as suggested by some historians. Instead we see the Hellenism of his wonderful notebooks being only achieved by a devotion profound enough to survive the severest of discouragement.

When we thus regard Archimedes and Leonardo as sharing across seventeen centuries the point of view which we now call modern, and notice the fragmentary incompleteness of their contact, we cannot fail to be struck by the irony of one detail. Heiberg discovered in 1906 the lost Archimedean MS. containing the anticipation of the integral calculus. It would have been greeted even more enthusiastically by Leonardo if he had been aware of its existence. It is essentially a mathematical method based on a mechanical picture, giving his geometry an empirical instead of a formal bias. This document would, more than any other, have justified the Archimedean trend of Leonardo as opposed to what might reasonably be termed the Apollonian outlook of the Moslem transmitters of Greek science.

Chronology of the Drawings and Researches

For the initial obtaining of facts relevant in a first approach to this problem, the various elements of Leonardo's artistic and scientific inheritance have necessarily been treated as if they were distinct, and I have been ignoring the ways in which each stage in his evolution may have developed from a preceding one. But this procedure might become misleading if, for instance, I selected drawings from a particular period of his career as representative of the same mentality which appears in a piece of scientific work of later or earlier years. It is no part of this essay, concerned with one Leonardo problem alone, to repeat in any detail the biographical sequence which may be found in any of the published histories. We may, however, recall that he lived in Florence from birth (1452) until 1483, in Milan until 1499, migrated with various short

stays in Florence and elsewhere until 1506, was in Milan again 1506-1513, and after a short period in Rome was in France until his death in 1519. The chronology of the drawings throughout these periods is the most difficult and the most important of all studies in his art. It was seriously attempted by Dr. Anny Popp and brought to a state of precision by Sir Kenneth Clark in his Windsor catalogue, where e.g. the periods of silver point, red chalk, black chalk, pen and ink, are classified by critique of numerous examples. Chronology of the MSS. was earlier attempted by various workers, including Calvi whose *Manoscritti dal punto di vista chronologico* . . . is perhaps the most important single study. I abstract here certain considerations relevant to the present problem, without any attempt to reproduce a systematic treatment.

From Leonardo's famous 'testimonial' letter commending himself to Ludovico Sforza, we know that by the time he left Florence for Milan in 1483 he had already developed that part of his scientific curiosity which showed itself in engineering and technological invention. The earliest drawings whose chronology is reasonably estimated date from before 1480, when he was still under the influence of Verrocchio. These include already the character which I described under Type I of the drawings, as denoting anatomical expression of violent effort. For example there are some of the 'dragon fight' studies; again the Adoration of the Magi, one of the early unfinished paintings at Florence, has in its background some violent horsemen whose attitude exactly recurs in much later drawings of 1503-6. At that later time he was constantly preoccupied with such creations, possibly to be used in evolving the 'Battle of Anghiari'. In fact various periods associated with definite surroundings find themselves occupied with local or specific interests, such as his activity in architectural drawing while at Milan, and the grouping of horse studies while engaged on the Sforza monument.

The caricatures of Type V are found over more than thirty years, from 1478 to 1513: Clark considers the majority of those at Windsor to lie between 1485 and 1495. A fine example of the contrasting Type IV is the mysteriously serene Madonna group at Burlington House, possibly from about 1500.

But perhaps the most remarkable feature of any chronological scheme is the concentration of Type III, the drawings of cosmic disaster, towards the end of Leonardo's life. Clark dates the Windsor 'deluge' series after 1515, within a few years of his death,

though the hydraulics which constitute their basis occupied him most of his scientific life, being found in plenty in the Paris MS. B which is one of the earliest and dates perhaps from 1489.

In the chronology of his scientific writings it is soon found that technological projects abound in all the MSS., including the Codex Atlanticus whose leaves range from 1490 until 1518. But it is of interest to note that the culmination of his enthusiasm in pure science for its own sake is probably reached in his second Milanese period, 1506-1513. It is unlikely that he had sources of scientific reading other than in the Italian language until well into his first Milanese period, 1483-1499; the notes expressing his pursuit of first-hand Archimedean MSS., his demands for Graeco-Moslem work to be translated, and the time he even found to spare for grammatical study as necessary to understanding Greek writings, belong on the whole to his later life. Early in that latter stage Cesare's campaign of 1502 was taken as opportunity for first-hand study of Archimedean MSS. at Urbino, and it was after the temporary return to Florence during the second Milanese period, in 1508, that he was enabled to found upon Archimedes the final statics. It is at this stage that we have glimpses of an attempt to put together his notes into systematic treatises, of which consummation he had to be disappointed.

It will be consistent with the outlook which I ultimately ascribe to Leonardo that this later pursuit of Greek scientists was not merely a search for more teachers—he never regarded even their authority slavishly—but a search for kindred spirits who were lacking in contemporary society.

The Stages in Leonardo's Mental Evolution

In the light of the foregoing considerations, the previous chapters make it possible now to trace something of a sequence. The task is the next major one consequent upon the labours of Calvi, Clark, and others in separately elucidating the two sequences of his art and of his science, and we must now look for the sequence in impact of scientific temperament upon artistic production. It is, of course, unlikely that any first attempt at this will be permanent in its conclusions, but as a tentative beginning for basis of future discussion of this new problem the following outline seems definitely to emerge.

Leonardo appears to have possessed from the very earliest the two requisites of scientific and artistic perceptiveness, respectively an instinct for accurate observing, which he carefully trained and

exercised, and a sensitiveness to contrast, in particular to contrasts in the feelings of living things. I suggest that the latter is more probably the core of his position as artist, rather than the traditional 'sensitiveness to beauty' which blurs the main psychological problem of Leonardo.

As a youth this natural quickness of perception enabled him to master to an unprecedented standard the technique in draughtsmanship which the environment of the Renaissance could bring to him through Verrocchio, Pollaiuolo, and others whom I have mentioned. The habit of drawing began to link his observations not merely with artistic production but with the scientific interests carried by the Moslems from the Greek to his Italian predecessors. The combination expressed itself as the delight in experimental and graphical contriving exhibited by his inventive technology throughout the rest of his life.

But if his development had remained at that stage he would have been merely a more encyclopedic and ingenious Verrocchio. He would not have provided future generations with that fascinating contrast in drawings, or afforded much insight into the modern problem of interaction between scientific and artistic temperament. It is his later development, where a purely scientific ideal led him into the companionship of Archimedes and the Alexandrians, that makes him unique: he began to give cause for the complaint of contemporaries that there was no time left for art and that paintings begun were never finished because resolved into mere scientific experimenting. 'He is working hard at geometry and is very impatient of painting.' 'In short his mathematical experiments have so estranged him from painting that he cannot bear to take up a brush.' It is doubtful whether history offers any comparable example of progressive domination of all artistic interests by a scientific ideal which was at that time an anachronism. I shall attempt to show later that philosophical and religious interests, as well as artistic, came under the same influence.

The fantastic in his art, during this evolution of the complete scientific mind, seems to have developed from a mere plaything to the amazing devastation of the last or catastrophic drawings. I put forward the suggestion that the following item in his psychology may play a more important part than hitherto realised in linking his final scientific temperament to its artistic expression.

His obsession by the scientific appears to have controlled him completely by the end of the last Milanese period, and when it is compared with the mere technology of Verrocchio's young artist-

pupil, we see how inevitably its growth must have been accompanied by an increasing loneliness. When he first left Florence for Milan there was a circle of active investigators by no means severed from the artistic culture of the time, as exemplified by the geometer-artist and biologist-artist contemporaries and immediate predecessors whom I mentioned earlier. But by the time his own researches had spread over the unprecedented field which I outlined, he must have reached a point where conversation with outdistanced contemporaries and second-hand contact through them with the ancient scientists provided no longer an adequate companionship. We have to suppose that he looked the more urgently to the direct ancestors of his methodology, Archimedes and the others whose manuscripts had to be sought under the difficulties which I have described. For his method had then reached a stage when his outlook upon nature had isolated him from his age. Not only the range of facts of which he was sole master, but even more the Archimedean attitude towards the possibility of understanding nature, was rare and hopelessly in conflict with the reliance of contemporary artists and even many scientists upon convention and tradition and authority. He was surrounded by a civilised community who, intellectually speaking, knew scarcely a word of the language in which he lived and thought. He writes in extreme bitterness of them probably after 1513: 'You deceive yourselves and others, despising the mathematical sciences in which truth dwells, and the knowledge of the things included in them. And then you occupy yourselves with miracles, and write that you possess information of the things of which the human mind is incapable and which cannot be proved by any instance from nature. And you imagine that you have wrought miracles when you spoil a work of some mind and do not perceive that you are falling into the same error as that of a man who strips a tree of the ornament of its branches covered with leaves mingled with the scented blossoms or fruit.'

In a world where even the most advanced minds commonly ascribed natural phenomena to fantastic principles and emotionally coloured causes, he insisted that knowledge can only be a product of unprejudiced observation and be proved only if reduced to quantitative expression: there is scarcely any character in scientific history about whom this erected a more unsurmountable wall.

Chapter 18

Sources of Fantasy in a Scientific Mind

The Contrast with Greek Art

At the end of an earlier chapter a fundamental problem arose from contrasts between the strict naturalism and the fantastic in Leonardo's drawings. By using the material subsequently recorded it may now become possible to approach this problem with some hope of a first tentative solution. Why did a lifetime of pilgrimage in pursuit of scientific method entail such a startling outrage upon nature as his grotesque monstrosities, and why did his mind finally dwell upon catastrophe in spite of having experienced its vision of serenity?

Since I have associated his final outlook with that of Greek science, attained initially through Moslem and Italian teachers and later by first-hand acquaintance, the possibility cannot be omitted that the most puzzling of his drawings are due to some influence of Greek art. But quite a brief consideration is sufficient to prove this inadequate. The serene and the bestial and the tempestuous in his drawings are all foreign to Greek aesthethic principles. The Greeks did not etherialise their women, and even the decadence of post-classical sculpture never permitted the intrusion of anything like his intensity of strained effort and maniac horror, while cosmic subjects are relatively unknown in Greek art. It is true that gracefulness can be characteristically Greek, but in human form and not in the animal shapes so common with Leonardo. Serenity can also be Greek, but is pre-Alexandrian and belongs to an era with which Leonardo was not so acquainted. Hellenic, not Hellenistic, serenity was unselfconscious and did not carry such disturbing suggestion of mystery when it characterised the age of Pericles. In fact the serenity of Greek art is essentially reposeful, at the opposite extreme from the intense spirituality of Leonardo's expressions which sometimes even suggest the ecstasy of martyrdom.

Even where Greek artistic affinities are discoverable they must be ascribed to the natural evolution in him of similar character, rather than considered as learnt from any classical model. He was only rarely acquainted with the art of the Greeks, in spite of so

much familiarity with their science; except for the sculptural traditions utilised also by Botticelli, Ghirlandajo, Lippi, and other less modern among contemporary painters, his early experience under Verrocchio in the gardens of the Medici was probably his only direct access to specimens. His architecture, for instance, appears to have been as closely derived from Syrian and Oriental as from classical types, while the paintings of others such as Mantegna and even sometimes of Botticelli are far more deliberately Greek than anything by Leonardo.

Hence although Greek naturalism guided his science, and although the majority of his art belongs to the note-taking phase of the observing naturalist, that art is infinitely less Greek than his science. In fact naturalism in the ordinary sense might be held to break down entirely in the most striking of the types of drawings which I have classified. For instance Clark decides that only a small percentage of the so-called caricatures were drawn from nature. Further, many of the cosmic and bestial types correspond to nothing in external nature that he can have observed. Again, the intensity and the grace of the other types are present in our own experience—in rare moments of illumination—but it is notorious that he placed in his serene faces a mystery which subsequent ages have tried in vain to see consistently in living people.

We may retire behind the commonplace statement which credits the poet or artist with finding in an ordinary object many aspects to which the rest of us are blind. But it is tantalising to dismiss so summarily the most intriguing personality of scientific and artistic history, and the urgency of seeing where science and art can meet in the modern world forbids us to rest content with anything less than the most that Leonardo can teach us. If we are to see his unearthly drawings as an understandable product of the same mind which created the MSS., we must seek other sources for their inspiration.

At the outset of this enquiry care was taken against assuming that the detached scientist is himself devoid of feeling, and it will be also necessary to enquire whether Leonardo expressed any of his feelings in the form of deliberate sermonising or 'comment of public interest'. The comparison with Greek aesthetics therefore next needs supplementing by a comparison with the didactic tendencies in art which were prevalent in medieval and renaissance times.

The Contrast with Religious or Political Didactic Art

The exercise of a preacher's sardonic humour would account for a number of Leonardo's fantastic drawings, but not for the

prevalence and slightly varied repetition of the more extreme caricatures: it would also fail to make any of them belong to the universal scientific temperament which I have been at pains to exhibit. Leonardo is an extremely bad subject upon whom to fasten any attempt at converting a public by his drawings, unless we decided to create a second self whose tastes were completely at variance with the rest of him. He was never of the temperament to be a propagandist, and seems to have avoided all institutional association, whether religious or political, throughout his career. As example of his real indifference to political feeling there is commonly quoted his curt and entirely dispassionate recording of the fall and flight of his employer at Milan, which event in 1500 was not insignificant for Leonardo himself, as it sent him into new migration. McCurdy also points out that the burning of Milan at another change of rulers in 1512 seems to have stirred only a desire for sketching the spiral forms of smoke. It was long after his day, in the eighteenth century, that some of his horrors were adapted as personal or party satire, and malice seems strangely absent from his own work. Altogether it appears likely that the caricatures must be taken as abstract expressionism rather than as *Odium Theologicum* on behalf of any church or state, and whatever feelings were thus vented were not a symptom of attack on individual enemies or public institutions. There are relatively few detectable instances of deliberate allegory among the hundreds of drawings, the most striking exceptions being at Oxford in the library of Christ Church. It is significant that the examples which 'point the moral' most directly are also the examples which most lack the intensity characterising the types investigated in this essay. Apart from these few allegories there is an air about Leonardo's drawings which it is impossible to associate with the didactic horrors beloved of many renaissance artists. The art of illuminated MSS., of which monastic piety had been the potent inspiration, was beginning to decay in the time of which I write; it had often exhibited its by-product in many ingenious and morbid little infernos which blaze at us from brilliant pages, but Leonardo's drawings bear none of the stamp of their half-concealed sadism.

But if Leonardo was not normally the preacher or agitator, what can have been the fundamental urge which obsessed his spirit and reduced the conscious or unconscious recording of that internal nature to the sketching of unnatural designs?

The Freudian Theory

A famous attempt to assign a specific psychological place to the obsession of Leonardo has been the monograph of Freud, similar ideas to which pervade the larger treatise by R. A. Taylor, 'Leonardo the Florentine'. The complete lack of matrimonial interest in Leonardo's personal history, together with the fact that some of his faces could be regarded equally as feminine or as masculine types, was put forward by those writers as ground for regarding transformation of undeveloped sexual impulse as a dominant feature in his abnormal constitution. We are not here concerned with the evidence adduced in support of such theory, notably a particular interpretation of a single dream of Leonardo, because it is now recognised that dream analysis is a scientific problem with multiple solutions, each corresponding to the particular instinct towards which the attention of the analyst is directed. For instance, each sexual solution by a pupil of Freud has its counterpart in a solution by, say, a pupil of Rivers, where an instinct derived from self-preservation or other primary urge replaces the sex impulse. The only definite ground common to the several psycho-pathological schools is the assignment of dreaming and waking symptoms to a conflict between SOME instinct and its fulfilment. I therefore value Freud's monograph not so much for its conclusions, which I do not accept, but because it implies that Leonardo's personality does indeed contain some other conflict.

Since there are scarcely any artistic, literary, or historical data involving sex instinct in Leonardo, I consider it unscientific to ascribe to that particular instinct a greater responsibility than given to the 'investigatory' instinct. The latter is weak enough in the majority of people, but it has for some rare individuals the strength of a primary instinct, and is not necessarily the mere sublimation of another one as demanded by the Freudian school. It takes an *a priori* conviction to be able to discover traces of sex in Leonardo's works, whereas evidence of an unusually powerful instinct for investigating the universe calls aloud from innumerable examples throughout his entire writings and personal history. Seeking among possible causes of abnormality in Leonardo, it is most reasonable to select that which is known to have been constantly present in him. Hence we must look for any conflicts which involve the impulse of the investigator, and must try to realise any barriers which other feelings or factors of environment may have interposed between this impulse and its

harmonious adjustment to surroundings in the particular case of Leonardo.

Nature Worship and Intimidation

The instinct of the investigator raises one enemy from within himself which may cause internal conflict. *Prima facie* it supplies one reason why any scientist might find himself driven to feelings expressible in monstrous or cataclysmic art. The observer of external nature very soon becomes aware of the inevitability of the processes which unfold themselves before him, and if the study becomes an obsession the vision of law may end as intimidation by nature. Was Leonardo, at the core of his being, terrified by the relentlessness of the forces which he was elucidating?

Making full allowance for an element of this kind, I do not consider it the most complete account of the scientist-artist whose personality I have been endeavouring to realise, for the following reason.

There may commonly be felt an oppression with the mercilessness of natural forces and with their eternal uncontrollability by human effort, but the feeling is a first consequence of the study of nature and not often the final consequence. In the case of Leonardo, when later we consider his philosophy we find that the oppression is even transmuted into something very like worship. What seems to happen in many cases is that the life-long student of natural phenomena finds that he has made his peace with the destiny which he cannot control; he has earned his peace through insisting upon understanding the processes by which that destiny works itself out. The poet, or the reporter of other men's investigations, is left with the full weight of nature's inevitability, but the investigator himself has learnt tolerance of the material universe by the intellectual agony with which he has wrung from nature a partial understanding. It is his greatest and most spiritually abiding reward. In so far as Leonardo progressed towards the completely scientific temperament and made the supreme spiritual effort to grasp the detail of natural phenomena, by so much must that intellectual drudgery have liberated him from the intimidation which would obsess him as imaginative artist. Of all the naturalists of history Leonardo ought in the end to have come nearest to the stage where the mental oppression of the Storm has vanished in the overwhelming fulfilment of the instinct to enquire as to its origin. A very trivial instance of this may be quoted from a Leonardo MS. He was hunting prehistoric bones in a lonely

mountain cave, and 'There awakened in me two emotions, fear and desire, fear of the dark threatening cavern and desire to see whether there were within it any marvellous thing'. The fervour of research dwarfed the fear and he went on to study his find, ending with a characteristically ecstatic exclamation in worship of the Natural Law exemplified by the bones he had discovered.

Once again some source of desperation more consonant with the psychology of his peculiarly scientific temper must be sought, if we remain convinced that a profound feeling and not mere impishness underlies the contrasts of serenity and horror in the drawings. I propose to look for it next in the reactions to human behaviour which Leonardo's work may be held to have generated in him. We found him a keen observer of humanity, and the facts therein may have revealed conflicts of moral law in which the reconciliation of external nature did nothing to help him. If human nature rather than the non-human universe disturbed him into his moods of unquietness, we must proceed to seek an understanding in any philosophical and religious standpoint which could be attributed to him.

Chapter 19

Scientific Reaction to Irrational Environment

The Worship of Necessity

Any opinion as to the philosophical or the religious life of Leonardo must be carefully disentangled from two obstructive prejudices; both of these are founded on facts but also on restricted meanings of words in the description of those facts. Firstly he is sometimes said to have been irreligious, and secondly 'philosophy' in him is commonly considered as confined to natural science. The former error arose in course of controversy over the alleged adherence of the dying Leonardo to an ecclesiastical orthodoxy which he certainly abhorred throughout most of his life. His avoidance of the metaphysical definitions which had delighted the Schoolmen, and which overflowed from the Middle Ages into his time, certainly indicates that he played no part in dialectical disputes, religious or philosophical; it would have been contrary to his empirical tastes to have cared much for ontological speculation. But the fact that he shrank from religious institutions need scarcely blind us nowadays to impulses in him which were of a profoundly religious character. Similarly the lack of any writings to merit a prominent place in philosophic history ought not to absolve us from appreciating a very definite *Weltanschauung* of Leonardo. If these religious and philosophical elements in him can be discovered, they may even throw new light upon his art.

In science we found him anticipating principles of inertia, of action and reaction, of blood circulation, etc., not by detailed formulation but by implicit use of their consequences. Similarly in his philosophy there are not to be found any formulations of principle but a large number of random remarks and notes. These imply opinions which may be inferred from some of their consequences, as metaphysics commonly does carry over some of its results into ethics and aesthetics.

If one extracts some of those philosophical notes which are not merely facts of psychological observation—a kind to which I drew attention previously—it becomes not at all difficult to trace a

foundation of Leonardo's universe upon the Necessity of Natural Law. By Necessity he seems to mean the orderliness in which effect follows cause, and his relation to it is by no means confined to its adoption as methodological postulate for scientific investigation. We come to realise that the inevitability of law invoked in him an attitude of worship which is definitely religious in its subjective characteristics. It is important to recognise that this attitude involves an element of ecstasy and awe which is entirely different from the uneasiness and terror which may be ascribed to certain phases of the scientist's evolution. For this reason the worship of Necessity seems unlikely itself to create the feeling which underlies the catastrophic or monstrous drawings, although the world's rejection of this religion may in turn have given rise to Leonardo's horror and despair.

'O marvellous Necessity, who with supreme reason constrainest all effects to be the direct result of their causes, and by a supreme and irrevocable law every natural action obeys thee by the straightest possible process.' 'O wonderful, O stupendous Necessity, thou by thy law constrainest all effects to issue from their causes.' 'Necessity is the mistress and guide of nature. Necessity is the theme and artificer of nature, the bridle and the eternal law.' 'Nature is constrained by the method of her law which lives and works within her.' 'Nature never breaks her own law.'

Such exclamations express almost the only emotional exaltation to be found in Leonardo's writings, and it must therefore be considered astonishing that they have commonly been neglected in attempts to understand his mind. They also form a very likely philosophical or even religious accompaniment to the overmastering urge of his practical life, the detailed elucidation of sequences of cause and effect. Since his 'Necessity' seems to carry with it an 'Intelligibility', there remains no doubt as to why investigation of nature was the practice of his adoration. Applied science even becomes a human ministration to the orderliness of nature, as when he writes: 'Medicine is the restoring of harmony to elements at variance, sickness being the discord of the elements infused within the living body.'

I shall refer below to some rather novel juxtapositions in which Leonardo may be placed, relative to unsuspectedly kindred philosophers. But meanwhile some ethical and aesthetic consequences must be scrutinised, which may have a bearing upon his art.

Ethical and Aesthetic Consequences

Just as Leonardo had no interest in expounding metaphysical principles, so he also avoids formal statements in ethics and aesthetics, except as directions for particular items in practical behaviour. But again the random notes of his MSS. soon reveal the implicit background. He seems to have had no deliberated theory of right and wrong nor of beauty and ugliness, but all his instincts rose against any irrationality: he revolted against anything which refused to share in his worship of Natural Law, and against any behaviour which diverted living things from the course of natural self-fulfilment set before them as the gift of Law. 'Blind ignorance misleads us . . . O wretched mortals, open your eyes.' 'And you, O man, who will discern in this work of mine the wonderful works of nature, if you think it would be a criminal thing to destroy it, reflect how much more criminal it is to take the life of a man.'

One here begins to see the grounds for Leonardo's view of cruelty as a cardinal sin. It is to him an intellectual crime involving lack of appreciation of the order of nature; it brands the sub-scientific level of approach to nature. He looks to a future Age of Reason in which there will be neither cruelty nor hypocrisy, the two blasphemies against his worship of Law, and in his own age the worst thing that he can say of man is that it is the animal which persecutes its own and other living species.

His very anachronistic care for animal welfare was noticed by contemporaries in tales of his buying caged birds to set them free, and of his refusal to eat the flesh of slaughtered animals; if I have rightly interpreted his philosophy, these practices represent not only sympathy for suffering but horror at the unreason and the ugliness of disregarding the natural freedom which is the heritage of the living example of Law. The suggestion appears more plausible when we re-read in the light of it his famous 'prophecies'. In these Leonardo is appalled not only at cruelty to animal life but at the destruction of a plant's natural self-fulfilment. The remark concerning trees which bear nuts: 'Those which have done best will be most beaten and their children will be carried off and stripped and despoiled and their bones broken and crushed,' may be not simply a mere indulgence in childish fancy. It should be set alongside his remark on destructive methods of obtaining the honey of bees: 'Many will be robbed of their store of provision and their food, and by an insensate folk will be cruelly immersed and drowned.' Again, concerning sheep and cattle: 'From countless numbers will

be stolen their little children, and the throats of these shall be cut and they shall be quartered most barbarously.' 'I see thy children given into slavery to others without ever receiving any benefit.' Concerning beasts of burden: 'And in lieu of any reward for the services they have done for them they are repaid by the severest punishments and they constantly spend their lives in the service of their oppressors.' 'The many labours shall be repaid by hunger, thirst, blows, and goadings,' 'The time of Herod shall return; for the innocent children shall be torn away from their nurses and shall die of great wounds at the hands of cruel men.'

These comments on the exploitation of animal and vegetable products exhibit a profound depression and horror, whose significance is not diminished by the fact that Leonardo chooses to express himself in a childishly fanciful form of imagery. I suggest that the depression and the horror were very real and are the exact correlative to the exaltation and ecstatic worship with which he contemplated any unimpeded process of natural life. Since traditional explanations of Leonardo's fantastic drawings have been found to be inadequate, I consider that the fantastic aphorisms and prophecies must no longer be omitted from any view of his deepest feelings which could account also for the drawings. That Leonardo was 'mad' by common standards necessitates our taking the novel step of seeking significance in some of his grotesque phrases, if we ever hope to appreciate his grotesque drawings.

Since Leonardo had no systematic interest in philosophy, his categories do not correspond to conventional distinctions; if cruelty is the sin of impeding the freedom of living nature, it is identically an offence against his intellectual and his aesthetic instincts which expressed themselves in his worship of Natural Law. The other cardinal sin of hypocrisy may similarly be regarded equally as ethically or aesthetically condemned by Leonardo. He seems to have felt that the refusal to contemplate Nature honestly was wicked and also ugly in its illogicality, and that the refusal to respect nature's provision for living things was an intellectual sin as well as hideous in its cruelty.

Florentine and Milanese Philosophical Associations of Leonardo

Although Leonardo is excluded from histories of philosophy by his complete lack of expository power, it is rash to ignore the contemporary state of philosophy when attempting to penetrate below the surface of his personality. The individuality of the outlook

which I have attributed to him is not fairly judged without asking what chances he had of contact with more systematic thinkers.

The worship of Necessity and Natural Law was maintained in the case of Leonardo by his habits of observation and experiment, and we have found contemporaries of the Italian Renaissance contributing to the early growth of these scientific habits of his. But when in later centuries a religious attitude towards Necessity and Law, somewhat similar to that of Leonardo, played its part in detailed systems such as that of Spinoza, the genesis of those systems lies in metaphysical doctrines strangely foreign to the more technological companions of Leonardo's youth. It is a novel task, but one which cannot be escaped, to scrutinise the possibility that Leonardo himself may have been influenced by metaphysical forerunners of the later pantheists, in addition to his debts to the more congenial and more scientific pioneers already discussed. Even the speculations which he despised may have unconsciously assisted his empirical temperament to create the emotions of the nature-worshipper, which we have found strong in him.

The relevant items in the development of nature-mysticism are scattered over the long history of Neo-Platonism, with its combination of the Hellenistic and the Oriental, and with outlying European allies of whom Nicholas of Cusa was perhaps the most striking personality in the early fifteenth century. Neo-Platonic tendencies of that age must in turn be considered as affected by the Jewish intellectual movements which led through the Kabbala, and also many Spanish combinations of Jewish and Moslem thought; none of these can safely be neglected in assessing the ancestry of Spinozism or of any modern philosophy of nature.

Now side by side with the technological aspects of the scientific Renaissance in Italy, in which flourished the biological and physical artists whom I discussed, there was in the Florence of Leonardo's youth a school where Neo-Platonism and even Jewish and Moslem metaphysics were discussed with sympathy. This was the Academy started by Cosima de' Medici in 1459 and directed at first by Marsilio Ficino. In spite of sundry falls into disfavour and disaster it undoubtedly exercised an inescapable influence over Florentine culture of the immediately following generation.

It is not surprising that Leonardo's empirical and anti-authoritarian temperament leaves us no acknowledged trace of any association with this school: he was probably irritated by it and contemptuous of it. But it is impossible that he was unaware of its existence, and of the ideas which formed the commonplace of

its discussions, during the twenty-four years of its history that he spent in the same city. However uncongenial the means by which the ideas were derived, their reiteration in the hearing of certain kinds of scientist might be expected to stir just those emotions towards nature which we have quoted from Leonardo's note-books. Therefore we cannot exclude the possibility that his outlook was affected by second-hand contact with so lively a contemporary circle: it may be recollected that the patron of the Academy was actually of the family to whom Leonardo owed so large a portion of his life's employment.

At Rome and in other Italian cities there were lesser academies growing up, for the discussion of Platonic or of Aristotelian metaphysics, with which Leonardo must also have made acquaintance during his shorter periods of residence in those places; but at Milan, where he arrived in 1483 and lived with interruptions for twenty-three years, there was no exactly corresponding organisation at the time. Philosophers existed there without such a direct imitation of a classical School, and perhaps worked more individually. But the printing press, in Italy by 1465 and at Milan itself from 1471 onwards, was beginning to spread the subjects of current discussion beyond local and manuscript circulation; philosophical topics were not so limited by the pursuit of solitary MSS. as in our previous Archimedean instance, and bibliography in the hands of discriminating critics such as Valla was not so hazardous. Some of the works of Nicholas of Cusa were printed as early as 1476, compared with the printing of Archimedes in 1544: it is possible that Leonardo, who would seize with avidity upon the *De staticis experimentis* of Nicholas, would also proceed to read the same author's *De docta ignorantia* and *De Visione Dei* with its Neo-Platonic mystical attitude to Reason and Nature. Nicholas was personally acquainted with Toscanelli and other scientists associated with Leonardo's early years, and since we recollect that Copernicus and Kepler far later were pervaded by Neo-Platonic and Pythagorean survivals, these may even more probably have touched Leonardo, empirical scientist though he was.

The suggestion that Leonardo may not entirely have escaped such influences derives encouragement when we regard the medley of extreme empiricism with mystical superstition in his far cruder contemporary Paracelsus. With the latter's anti-authoritarian worship of the Light of Nature, Leonardo would have had considerable sympathy, if it had not come a few years too late for him. Paracelsus—eccentric to the point of insanity—is even said to have

burned the text-books on biology, Galen, and Avicenna, as demonstration of insistence upon learning from personal experimentation alone.

At Milan the Cardan family were perhaps the nearest philosophical associates of Leonardo. In recollecting my previous suggestion that the younger Cardan may have transmitted the little of Leonardo's science which did descend, it is relevant to notice that the *anima mundi*, or Neo-Platonic conception of a Soul of the World, is prominent in the writings of that philosopher shortly after Leonardo's death.

We may in these ways compare the philosophical attitudes, both of technologists and of mystics of the Renaissance, with the emotional fragments which imply a philosophy in Leonardo's note-books. It soon becomes clear that however little Leonardo learnt from or gave to either type of thinker, he possessed to an extreme the insistence upon experiment which was the end towards which the technological schools were tending. It is equally clear that he went as far as any of the mystical schools in religious adoration of the object of natural knowledge. These comparisons then place him at the meeting point of current intellectual tendencies. Around him, however isolated from him, Florence and Milan were alive with the notions underlying religious pantheism as well as those upon which the technique of modern science was about to be founded: but since he comprised within himself so much which belonged to two mutually unsympathetic types of mind, his philosophical position intensifies, instead of relieving, the solitude and even the conflicts of his intellectual life.

Leonardo and Anticipations of some early Modern Philosophers

Through the Cardan family, Leonardo's worship of Natural Law may in turn have affected the many sixteenth- and seventeenth-century philosophies which culminated in the pantheism of Spinoza. But any such influence must have been anonymous. It is likely enough that authors of naturalistic writings such as Giordano Bruno had heard of Leonardo, and he was even perhaps known to others who regarded Natural Law as a new basis for human legalism, such as Grotius and Hobbes. But it is unlikely that any of them heard of him except as an artist. His passionate invocations of Necessity are modern discoveries from the MSS. which were then passing through the vicissitudes of private exchange which I outlined in an earlier chapter. But Bruno's Soul of the Universe is a conception almost identical with that of Cardan; the latter

was educated personally by his father, the friend of Leonardo's testator Melzi, and as a nature-concept accessible to Reason Bruno treats this fanciful notion in almost Leonardesque terms. If, however, Cardan carried anything of this from the family friendship, it was not acknowledged by name: he refers cynically to the man who 'Was a failure at flying but an excellent painter'.

A sequence from Nicholas of Cusa to Bruno and from Bruno to Spinoza has often been commented upon by historians of philosophy, and Leonardo published nothing whatever to insert himself into that sequence. But if Bruno thought so highly of Nicholas who was also Leonardo's close predecessor in *De staticis experimentis*, and if the spirit of Nicholas was also in the Neo-Platonic school of Marsilio Ficino in the Florence of Leonardo's youth, we have to allow the possibility that Leonardo contributed to the *Zeitgeist* which permeated Florence and Milan. The similarity of wording in writings of Nicholas of Cusa, Cardan, even Paracelsus, Leonardo himself, Bruno, and finally Spinoza, are difficult to explain without some community of intention among such divergent personalities, even though it remains impossible to decide which of these individuals had learnt consciously from any of the others.

The supremely disciplined mind of Spinoza is certainly the most distant of these in superficial characteristics, but it should, I think, be recognised that he gave systematic formulation to some feelings towards nature which Leonardo had buried in random notes. I suggest that the two worshipped the same thing, and that the methods by which each approached the object of his worship are not dissimilar in spite of Spinoza's Rationalist and Leonardo's Empiricist temperament. There are remarks in Leonardo's MSS. such as 'The senses are of the earth, the Reason stands apart from them in contemplation,' 'Desire should not be of this world,' etc., which might almost have been quoted from Spinoza's classification of knowledge underlying his Ethics. Spinoza is the classic instance for all time of the power which the mystical mind acquires when once it ceases to despise scientific method. Hence it seems possible to suggest that the devoted scientist of fifteenth-century Italy and the *Gottbetrunkener* pantheist of seventeenth-century Holland may be psychologically closer to each other than their non-interseeting paths in the history of European culture would allow. It is certain that no two characters of history have been more closely united in finding 'Necessity' to be the aspect of the universe, the most compelling of adoration.

The Art of Serenity and of Despair

If we accept this philosophical accompaniment to Leonardo's science, and try to appreciate his vision of an orderly and understandable Nature, we must also admit the disillusionment that must have been forced upon him by his surroundings. The disillusionment was the more bitter the deeper his devotion to the vision. An earlier conclusion left us with a picture of his isolation, on an intellectual plane which few scientific contemporaries were capable or desirous of sharing. Now it is sometimes fashionable to suppose that the atmosphere of any intellectual solitude is not conducive to human feeling. But the 'ethical' quotations convey the disturbing certainty that Leonardo never attained that detached freedom from emotion; he contemplated too often the ugliness of cruelty in an age of unreason.

The central problem of Leonardo's art had been propounded in the strange contrast between his fantasy and his naturalism. This contrast would have been understandable as exhibiting the alternations of serenity and horror in a sensitive and expressive mind subject to continual conflict, but previously suggested sources of such conflict seemed inadequate to his peculiar temperament. Now that we have discovered that which evoked a religious attitude in him, and have also realised his bitter reaction to prevailing blasphemy of that religion, it seems possible that we need seek no further for the source of the severest mental conflict.

I have suggested that his feeling towards the inevitability of Natural Law was not of the character of an intimidation, but instead an ecstasy of worship for that which he called Necessity and which he passionately believed in as 'understandable'. As powerful as any intimidation, therefore, must be reckoned his exasperation at the unwillingness of contemporary society to share in this unusual passion for the reign of law. His universe held out to him the calm supremacy of the thinker who comprehends even the powers which must destroy him, and one phase of his drawings may reasonably be taken as expressing the mystic serenity which knowledge in itself can occasionally afford to the rarest mind. But at the same time he found humanity neglecting with contempt the orderliness which was holiness to him, and he was constantly made aware that his ideal was being polluted by cruelty and deliberate unreason. Comprehension of physical laws may have reconciled him to their ruthlessness and allowed his feelings to end in worship rather than terror, but any comprehension of psychological laws

he may have attained did not blind him to moral evil. He seems, in spite of his pathetic eulogies of patience, to have been unable to teach himself a complacent acceptance of such a situation; in fact he failed in the greatest self-adjustment to environment that he was called upon to make. I submit that this failure constitutes as potent a source of horror and loathing as ever condemned any man to the stigmata of mental conflict.

Without belittling Freud's ascription of many conflicts to sex-starvation, other instincts must be admitted which are by no means negligible in abnormal individuals such as Leonardo. Actually with Leonardo the aesthetic attraction of the intellectual ideal of natural law and order seems to have reached the magnitude of the most overmastering passion. Since this passion was of such strength in him, beyond the experience of most men, its frustration may well have been enough to inspire an art which contains the most maniacal violence and the most frightful distortions, when he became oppressed beyond endurance: and we now know from his MSS. that the hideousness of unreason and of cruelty were the sources of his most profound oppression.

Detailed interpretation is of course beyond the stage of this initial suggestion. It may never become possible to decide whether his outbreaks in drawing were unconscious self-expressions or deliberate recordings from introspective observation of his own passionate reactions to nature and to man's unnatural crimes. The latter alternative would separate him utterly from his Greek affinities, as it is a modernity quite out of harmony with their unself-conscious simplicity. I have already submitted that his habit of drawing seems spontaneous rather than deliberate, in the sense that it does not set out to convert in any spirit of religious or political didacticism.

Nor is it desirable to say whether his exasperation was much intensified by inadequate public recognition of himself as well as of the ideal which he worshipped: bitterness was bound to be somewhat sharpened by the extreme isolation which I have described. Some writers have tried to picture him as sublimely indifferent to outside opinion, but a number of passages from his note-books, drafts of letters, etc., indicate that he was by no means oblivious of rewards. 'Works of fame by which I could show to those who shall see them that I have been'; and regarding his flying-machine, 'The great bird will take its flight, filling the whole world with amazement and filling all records with its fame.' He was not an ascetic, and such quotations prevent us from complacently equipping him

with the indifference to isolation which seems to have sustained Archimedes and other historical examples of intellectual solitude. Nor can we be blind to the psychological effects of nagging demands that he should produce finished works of art when impatient to experiment both in art and in science: this situation is explicit in contemporary accounts and in his own drafts of letters excusing delays in the execution of commissions. He is at last constrained to sum up a long term of employment, 'The Medici created and destroyed me.' But whatever the share of this in his loneliness, any vanity and disappointment of personal ambition play a minor part in his notes compared with the devoted glorification of the rationality of natural laws, and the despairing horror at men's rejection of any such ideal.

Whereas there can be no doubt that in some of Leonardo's drawings we look into worlds more exalted and more debased than our own, there can never be any proof that these worlds are his symbols of man's struggle to understand the order of nature and of man's perversity in polluting that order by cruelty and wilful blindness. But those drawings do irresistibly suggest mental storms of disillusionment and despair and loathing, together with a recurring conviction of the possibility of self-mastery. It cannot be irrelevant, therefore, that we discover from elucidating his mental history that circumstances did condemn him to such storms. Any valid interpretation of Leonardo must take account of those features which most distinguish him from other men, and I suggest that a foundation of his mental pathology upon his scientific life in a hostile environment does fulfil this requirement: possibly it is the only hypothesis which has so far made serious attempt to fulfil it.

Leonardo as Scientist in his Philosophy and therefore in his Art

I recapitulate briefly the argument of the preceding chapters. The essay as a whole is concerned with a new approach to the problem of seeing a single personality in Leonardo. I began by recognising that it must be sought under the contrast between his naturalistic art and his drawings of either serene or monstrous unearthliness.

In the traditional dilemma as to whether Leonardo's art is that of a scientist or his science that of an artist, I found it necessary to re-assess his scientific achievements and methods and the channels through which he was influenced by predecessors. The result exhibits Leonardo as gradually extending a technique of scientific observation and analysis over the whole of experience, and

developing a method closer to that of Alexandrian Greeks such as Archimedes than to the European and Oriental predecessors through whom the Greek science was transmitted to him. Many of his drawings can then be seen to partake of the character of naturalist's notes associated with this observing technique. The more fantastic examples, however, appear to contradict this dominant habit in Leonardo. They also diverge sharply from the character of Greek art and of medieval religious or satirical art. I reconsidered the attempts which have been made to postulate an appropriate pathological origin for the more strange of the drawings. Examination of the Freudian theory indicates its inadequacy. I also found inadequate any view based on obsession by the terror of an uncontrollable cosmos: when such terror does arise as a by-product of scientific study, it belongs to a different stage from that reached by Leonardo.

Finally a more consistent account of him was sought by tracing the philosophical outlook which his MSS. exhibit as accompaniment to his science. He was certainly obsessed by the inevitability of Natural Law, but towards worship rather than towards terror. He can even be shown to have developed something approaching the religious pantheism which culminated in the very different philosophy of Spinoza. But whereas the forces of inanimate nature seem not to have dismayed him, many of his notes are full of horror at finding human nature blaspheming the sanctity of that which he worshipped, and to this situation he seems never to have become reconciled. It appears to be not inanimate violence in all its implacability but the ethical and intellectual and aesthetic tragedy of human failure to respect natural law, which condemned Leonardo to an unquiet mind even in the presence of his serenest visions. He was not adequately comforted by realising that human delinquency itself exemplifies some natural law which cannot be broken, although he seems free from the pre-scientific notion of Law as a command to be either obeyed or disobeyed at will. When the MSS. record those occasions of profound feeling, we are reminded of our initial warning that a scientist is not always without emotion, and we have to conclude that Leonardo's studies in psychology did not bring the peace of understanding which came from comprehending the vastest of physical but non-moral phenomena.

We find in much of his philosophical fragments an expression of this conflict between ecstatic acceptance of the Necessity of Natural Law and revolt against the unreason and cruelty and

ugliness of human contempt for its fulfilment in the orderliness of animal and vegetable life. I have put forward the suggestion that the same conflict may be expressed in the contrast between celestial and infernal types of his more mysterious drawings.

This view would, for instance, set parallel to the drawings of cosmic disaster such phrases from his MSS. as the following. 'There shall be nothing remaining on the earth or under the earth or in the waters that shall not be pursued and molested or destroyed . . . O earth, what delays thee to open and hurl them headlong into the deep fissures of thy huge abysses and caves and no longer to display in the sight of heaven so savage and ruthless a monster.'

If this interpretation is correct, it brings Leonardo into more than one previously unsuspected relationship; not only does he foreshadow the pantheist worship of Necessity and of the ethical and aesthetic virtues in Spinoza's intellectual ideal, but his fundamental emotions are also reminiscent of Dante. If we rid ourselves of their glaring but superficial differences, and exchange obsession by Natural Law for an obsession by an anthropomorphic legality, we find Leonardo and Dante each dominated by the beauty of a universe in harmony with law, and by the horror of men's vain attempts to despise law. They have in common the genius for symbolising these feelings in their arts, pictorial and poetic respectively; the unearthliness of each of them represents the vision of law and of human reaction to law, a vision responsible for the ecstasy and the despair of the artist.

Conclusion

A scientific approach to experience is becoming universally available, and its consequences both in technology and in philosophy are inevitable even if we do not always decide that they are desirable. Simultaneously, in the stress of dangerous years, men are increasingly intent on exploring the imaginative in arts and even religions, some with devoted enthusiasm and some with critical scrutiny. A tangle of incompatibilities is therefore now inherited from the traditional antagonisms between our logical and aesthetic reactions to experience. Throughout the foregoing groups of essays there has frequently recurred the suggestion that some of these antagonisms might become understandable and even might become reconciled: the ground for such synthesis is to regard science and art as each a mode of communication of mental imagery by pattern or structure in some selected medium. But the suggestion will only be of service to the modern crises of feeling and of thought if there is also recognised the danger of misreading the limits of association between science and art: the overlap of logical and imaginative can be as disastrous today, crippling art and sterilising science and philosophy, as in less subtle civilisations where primitive science and philosophy were not so divorced from the arts.

This thesis decides the sequence of the present four groups of essays. The function of pattern and structure and form, for instance in sculpture, decoration, music, and poetry, emerged in Part I and was illustrated by the five studies of Part II. When this function can be fulfilled, the call for an artist to represent objects or scenes of external experience is overridden by the need for his imagination to stimulate a responding creation in the minds of the public. This creation's independence of external fact was emphasised, and criteria of realism were therefore transferred from any correspondence with outside phenomena to coherence and character in the imaginative consequences for the receptive mind. Hence the significance of ancient Chinese or medieval European carving, and of some modern poetry and stage arts, was not found in their representational content but in properties akin to those of the most abstract music. A detailed comparison was made between

application of this notion throughout the history of art and the emergence of 'communicability of natural law' in the logical patterns of recent physical sciences. One sharp distinction was drawn between the communications of scientific and imaginative pattern: it was decided that a single work of art must invoke different images in different minds, whereas a scientific theory finds its validity in the identity or the correlation between calculations or experiments carried out by its means under all possible varieties of circumstance. But it was noticed that many of the most fruitful concepts of science are as remote from direct sense experience as those of the most fantastic art; their legitimacy in each case lies in the power to evoke coherent mental imagery.

Recognition of affinities between scientific and aesthetic aims or methods carries danger as well as enlightenment. Scientific development can be stifled by mishandling of these affinities, as when the aesthetic appeal of an exquisite geometry perpetuated an obsolete astronomy: in Part III historical instances of this have been investigated through some research into early migrations of scientific culture. It was concluded that subtle misreadings of the interdependence of aesthetic and logical enthusiasm have reached even the philosophy of the twentieth century, and may be better understood in the light of parallel mistakes made by the artist-scientist-philosopher groups in certain medieval Oriental civilisations.

In spite of recent revaluations and devaluations, Leonardo da Vinci remains the prototype of modern scientific instinct, occurring in a personality with unprecedented artistic technique for self-expression. But this instinct was frustrated by non-scientific environment, and as Leonardo failed in his mental adjustment thereto, he left us documents expressive of alternating exhilaration and despair. Such a view offers a novel approach to Leonardo's enigmatic personality, and this most instructive but intimidating character in the history of science or art is so full of suggestiveness for our current perplexities in the social relations of science, that Part IV is given up to its discussion in detail not hitherto available. The importance lies in the fact that the misfits of science to society will remain a problem, even to a coming generation which will have learned to correlate its science, art, religion, and philosophy. The correlation itself will have been achieved when we recognise the universal tendency of the human mind to symbolise its experiences, and when we recognise that any stage in science is only a transient foreshadowing its supersession by a further advance, and

when we recognise that realism in art can be judged only by the human consequences of its imaginative effects. But even then we shall still be faced with Leonardo's uncertainty in scientific obligation to an unscientific world—the ineradicable source of loneliness for the logical mind.

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The following lists are, of course, brief and selected: other authors are mentioned at the appropriate places in the text. References are only here given when the subject (such as Oriental archaeology) is not one of common accessibility, or where (as in the Leonardo and Spinoza studies) the vast jungle of literature suggests that a few pointers to the most important items may be desirable.

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Chapter 7

The accompanying illustrations are from plates published by 'Tel' of Paris and by Etienne Houvet at Chartres. Grateful acknowledgement is here made, with regret that the state of Europe prevents any direct communication to request permission.

In addition to various works of Houvet, the following among others have contributed to the recollection of Chartres and to evolving the ideas of the present chapter.

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(The last three contain illustrations of the instruments of 1279.)

Chapter 13

Among introductions to Chinese philosophy, those by Arthur Waley are the clearest. To Spinoza, the best introductory volumes are those by J. Caird (1910), Leon Roth (1929), and Alexander

Shanks (1938), together with the edition of Spinoza's letters by A. Wolf (1928) and H. F. Hallett's study called *Aeternitas* (1930).

Readers wishing to pursue the anomalies which I have imputed to current philosophy must attempt McTaggart's *Nature of Existence* (2 vols. 1921–7) and C. D. Broad's *Examination of McTaggart's Philosophy* (3 vols. 1933–8).

Chapter 16

Sir Kenneth Clark's *Windsor Catalogue* (2 vols., 1935) and *Leonardo* Essay (1939) are indispensable in studying the Leonardo drawings, and contain critical bibliography of all previous work. Other collected reproductions were published by Hind, Müntz, Popp, Sirén: the rare 'Grosvenor' and Royal Italian collections, together with Berenson's Renaissance volumes, are the best when available. Readers must beware of books containing drawings by Leonardo's imitators and not distinguished as such.

Chapter 17

Of the many editions and selections from Leonardo MSS., two recent sets supersede all earlier publications, the two vols. of McCurdy (1938) and the two vols. of I. A. Richter modernising the older work of J. P. Richter (1939). Calvi's Italian study of the MSS. is indispensable for the chronology. The best and wisest study of Leonardo's science is still the small book by Séailles, though a valuable English work by I. B. Hart appeared in 1925. Entirely different theories from mine may be found in the books by Freud, Taylor, and Thorndike.

The background of migrations of early science and its manuscripts, developed in Chapters 11, 12, 17, would be indecipherable without the many researches of C. H. Haskins, George Sarton, and Sir T. L. Heath, whose writings are eminently readable.

Index