Jacob Bronowski

The Common Sense of Science

Faber Finds

JACOB BRONOWSKI

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Contents

CHAPTER 1

Science and Sensibility

1

I CAME to England when I was twelve, and when I landed I could speak, rather badly, two words of English which I had learned on the channel boat. I did not read English at all easily for two or three years after. The first writers in whom I was able to distinguish what my patient schoolmasters called style were, I remember, Macaulay and Joseph Conrad. I do not remember now whether at that time I was also able to distinguish between their styles. I read greedily, with excitement, with affection, with a perpetual sense of discovering a new and, I slowly realized, a great literature. But I was handicapped then, and I have been ever since, by the disorderly way in which I fell upon my masterpieces: Dickens cheek by jowl with Aphra Behn and Bernard Shaw, and elsewhere leaving tracts of neglected literature by the century. To this day I have not read the Waverley novels, and in consequence I have remained rather insensitive to historical romance, particularly if much of the conversation is in dialect.

I make these confessions because they seem to me to bear on many stories besides my own. The difficulties which I had are not mine alone, and they are not in any special way literary difficulties. On the contrary, what now strikes me about them is their likeness to the trouble which other people have with science. At bottom my difficulties in facing a strange literature are precisely the difficulties which all intelligent people today have in trying to make some order out of modern science.

We live surrounded by the apparatus of science: the Diesel engine and the experiment, the bottle of aspirins and the survey of opinion. We are hardly conscious of them; but behind them we are becoming conscious of a new importance in science. We are coming to understand that science is not a haphazard collection of manufacturing techniques carried out by a race of laboratory dwellers with acid-yellow fingers and steel-rimmed spectacles and no home life. Science, we are growing aware, is a method and a force of its own, which has its own meaning and style and its own sense of excitement. We are aware now that somewhere within the jungle of valves and formulae and shining glassware lies a content; lies, let us

admit it, a new culture.

How are we to reach that culture, across its jargons, and translate it into a language which we know? The difficulties of the layman are my boyhood difficulties. He opens his newspaper and there stands a revelation in capitals: THE ELECTRONIC BRAIN, or SUPERSONIC FLIGHT, or *Is there life on Mars?* But capitals or italics, the revelation remains in code for him. The language is as strange to him as *The Anatomy of Melancholy* was to me at fifteen. He has only the smallest vocabulary: a smattering from other popular articles, schoolboy memories of the stinks lab, and a few names of scientists sprinkled at random across history. His history, which might have given an order to it all, is the most maddening of his uncertainties. I knew no English history, and therefore I could not make sense of literary development. How well I recall the helplessness with which I faced a list of names such as Marlowe and Coleridge and H. G. Wells. I could not make any historical order of them. It is hard to visualize my difficulty; yet just this is the difficulty which every reader meets when he sees the names of Napier, Humphry Davy, and Rutherford. These three scientists were contemporaries of the three writers, and they were by no means lesser men.

A knowledge of history of course, even the history of science, will not do duty for science. But it gives us the backbone in the growth of science, so that the morning headline suddenly takes its place in the development of our world. It throws a bridge into science from whatever humanist interest we happen to stand on. And it does so because it asserts the unity not merely of history but of knowledge. The layman's key to science is its unity with the arts. He will understand science as a culture when he tries to trace it in his own culture.

It has been one of the most destructive modern prejudices that art and science are different and somehow incompatible interests. We have fallen into the habit of opposing the artistic to the scientific temper; we even identify them with a creative and a critical approach. In a society like ours which practises the division of labour there are of course specialized functions, as matters of convenience. As a convenience, and only as a convenience, the scientific function is different from the artistic. In the same way the function of thought differs from, and complements, the function of feeling. But the human race is not divided into thinkers and feelers, and would not long survive the division.

Much of this quarrel between science and soul was trumped up by the religious apologists of Queen Victoria's day, who were anxious to find science materialistic and unspiritual. The sneer that science is only critical came from others. It was made by the timid and laboured artists of the nineties in order that they might by comparison appear to be creative and intuitive. Yet this finesse could not hide their own knowledge that the best minds were already being drawn to the more adventurous practice of the new sciences: a movement which Peacock had foreseen seventy-five years before in *The Four Ages of Poetry*.

The arts and the sciences ever since have been in competition for the most lively young brains. This competition is itself the clearest evidence that good minds can fulfil themselves as well in one as in the other. Here in fact is one of the few psychological discoveries of our generation to which we can hold with a reasonable certainty: that the general configuration of intelligence factors which distinguish the bright from the dull is the same in one man as another, in the humanist as in the scientist. We are divided by schooling and experience; and we do differ, though we differ less, in our aptitudes; but below these, we share a deeper basis of common ability. This is why I write with confidence for laymen and scientists, because the reader who is interested in any activity which needs thought and judgement is almost certainly a person to whom science can be made to speak. It is not he who is deaf, but the specialists who have been dumb – the specialists in the arts as well as the sciences.

Many people persuade themselves that they cannot understand mechanical things, or that they have no head for figures. These convictions make them feel enclosed and safe, and of course save them a great deal of trouble. But the reader who has a head for anything at all is pretty sure to have a head for whatever he really wants to put his mind to. His interest, say in mathematics, has usually been killed by routine teaching, exactly as the literary interest of most scientists (and, for that matter, of most non-scientists) has been killed by the set book and the Shakespeare play. Few people would argue that those whose taste for poetry has not survived the School Certificate are fundamentally insensitive to poetry. Yet they cheerfully write off the large intellectual pleasures of science as if they belonged only to minds of a special cast. Science is not a special sense. It is as wide as the literal meaning of its name: knowledge. The notion of the specialized mind is by comparison as modern as the specialized man, 'the scientist', a word which is only a hundred years old.

Therefore I have in mind as I write a reader who is less interested in the sciences than he is in science. There was in the last century a tradition of self-teaching in the Mechanics' Institutes which in its time was a just cause for pride. But the tradition is gone and its going now is not a loss, because the interest in science has widened. We are all aware of the widening. Those who hanker after a knowledge of science today are not looking for technical information. They are no longer unfortunates who would have liked to work in a laboratory too, if fate had not sent them into a mill at twelve. I take it for granted that those who take up this book are well content with what they know and do, and are not thinking of themselves vicariously as the white-coated hero of a second feature about the discovery of Compound E. And I do not assume that they must necessarily be fascinated by the marvels of the electron microscope or of radio-active iodine. I think of them as people aware that the world into which they were born is changing during their lifetime, and who have about this change the same curiosity which they have about what is new in their closer neighbourhood – in literature or the arts or local politics or the business of the tennis club.

Few people today are really in doubt about the scale and the lasting importance of this change. But many people push it to the back of their minds, resolutely or in embarrassment. And much of the time they fear to face it, because they are afraid to acknowledge that this movement is changing their lives, is washing away the landmarks of their familiar world, rising round their values, and in the end drowning the selves which must last them their lifetime. Yet these fears are less fears of the social change which science is working than simple personal fears. They are afraid, we are all afraid of being left out. We are afraid that something is happening which we shall not be able to understand and which will shut us out from the fellowship of the brighter and younger people.

These fears I believe are groundless. I believe that it is easy for a man who likes conversation and to read the second leader now and again to be comfortable with the large ideas of science: as easy as it is for a scientist to have a fancy for biography. The difficulties are those of language and the personal fear of what is unfamiliar. These are merely fed by those enthusiastic scientists who write as if the layman were to be pitied, and treat him as an erring would-be scientist who ought to be converted to an interest in the nucleus. I have no such reader in mind. I think of my readers, scientists as well as laymen, as balanced people who see about them the world in movement, and who want to know enough about the forces of science outside their own neighbourhood to assess their part in

that profound and total movement of history.

4

Many people affect to believe that science has progressively strangled the arts, or distorted them into some unpleasant ‘modern’ form; and therefore that the arts can be revived only by throwing over science. Often of course this is merely an elderly sentiment in favour of the art of our younger days, and the real scapegoat is not science but change. But even where the sentiment is less partial, it springs from a misunderstanding of progress in art and science. Science today is plainly more powerful than, let us say, in the time of Isaac Newton. Against this, the arts today seldom reach the height of, say, his contemporary John Dryden. It is therefore tempting to conclude that science continually outgrows its older ideas, while great literature remains permanent. But this is a hopeless muddle of concepts. Newtons are no more plentiful today than Drydens; and the work of Newton continues to stand to modern science in precisely the relation that the prose of Dryden stands to modern prose. Dryden and Newton each revealed a wholly new set of possibilities in their forms of knowledge. Both are classics in this sense, that they were at once pioneers and men of great achievement. And neither is a classic in any other sense.

The belief that science destroys culture is sometimes supported by historical statements that the arts have flourished only when the sciences have been neglected. This thesis is so directly contrary to history that I find it difficult to begin to debate it. What is this golden age of art untarnished by the breath of rude mechanics? Where did it exist? In the East? The civilizations of Egypt, of India, and of the Arabs belie it. The only oriental poet at all well known in England, Omar Khayyam, was a Persian astronomer. In the West? The culture of the West begins in Greece; and in the great age of Greece, art and science penetrate one another more closely than in any modern age. Pythagoras lived before Aeschylus had created Greek drama. Socrates taught when that drama was at its greatest; and is Socrates to be claimed by art or science? And Plato, who did not tolerate poets in his ideal state, was a scholar when Aristophanes closed the eyes of Greek drama. The example of these men in science as much as in art set the modern world afire in the Renaissance. And the type and symbol of Renaissance man was from the beginning and remains Leonardo da Vinci, painter, sculptor, mathematician, and engineer. No man has shown more strikingly the universality and the unity of the intellect.

In England we put the golden age into the reign of Queen Elizabeth; and that characteristically was an age of commercial and industrial as well as of literary invention. Voyagers and adventurers like Sir Walter Ralegh were the Leonardos of that age; and Ralegh's own circle, which turned Christopher Marlowe into a rationalist, was dominated by a mathematician and astronomer, Thomas Hariot. For navigation is dependent on astronomy; it went hand in hand with the new speculations about the world and the solar system; and in turn, the voyages of the great navigators inspired the literature of Elizabethan England. The worlds of art and of science and the physical world unfolded then together. It was not by accident that the first table of logarithms was published within a few years of the First Folio.

Sixty years after the death of Elizabeth, another great age ripened in England, the age of Restoration literature. I shall have a great deal to say about that in this book, because one symbol of the age is the founding of what has remained the most important scientific society in the world. The meeting which founded it on 28 November 1660 opened with a lecture on astronomy, and the lecture was given by Christopher Wren the architect. The society was given its name, the Royal Society, and its motto by the most enthusiastic of its founders. He was John Evelyn the diarist. When the society wanted to encourage the use of simple and lucid prose, it appointed a committee which included a fellow of the society with a special gift for such writing. He was the poet John Dryden.

5

The golden ages of literature were in fact times of greatness when science and the arts went forward hand in hand. Has all this come to an end? Literary critics say Yes, it ended in England at the Industrial Revolution, somewhere between 1760 and 1800. Yet these critics date the Romantic Revival from some point between the death of Collins in 1759, which meant so much to Wordsworth, and the publication of the *Lyrical Ballads* in 1798. These two sets of dates are almost identical, and can it be reasonable to keep them in separate compartments of the mind? Is it really tenable to think of the Industrial Revolution as a kind of death? It gave our world its structure. It turned science from astronomy to what are essentially its modern interests, which hinge on the use of mechanical power. And it created in the romantic poets and the reformers what has remained our sensibility.

I say created our sensibility, although of course I have pointed only to the coincidence of dates: that Blake and Coleridge and Wilberforce were

after all contemporaries of Arkwright and James Watt. Against this, those who hold the illusion that pre-industrial England was more sensitive and cultured, point to the misery of the manufacturing age: women in mines, children in factories, the disasters of enclosure, famine, the Napoleonic wars, and political reaction. These were very terrible evils, but they are evils far older than 1800 and the machines. The labour of women and children for endless hours in their own homes is a commonplace in Defoe's journals in 1725. Yet the Augustan optimists of his day did not see it as matter for protest. But in the factory these evils became naked and public; and the driving force for reform came from the men of the mill, from Robert Owen and the elder Peel. We today are scandalized that boys went on climbing in chimneys for nearly eighty years after the heart-rending poems which Blake wrote about them around 1790; the last of the climbing boys, Joseph Lawrence, is still alive as I write. But the boys had been climbing for a hundred years before Blake without a line of protest from Addison or Gay or Dr Johnson. In their broad Augustan day, Scottish miners were legally still serfs, just as the miners of Greece had always been slaves; and neither civilization thought anything amiss. So today in China and India and other countries with few machines, life is brutal and laborious, and sensibility is unknown; I have seen it so myself, under the rusty thin surface of mechanization in Japan, for women and animals alike. It was the engine, it was the horsepower which created consideration for the horse; and the Industrial Revolution which created our sensibility.

6

Science changes our values in two ways. It injects new ideas into the familiar culture. And it subjects it to the pressure of technical change, in the way I have just been describing, until the whole basis of our culture has imperceptibly been remade. The invention of printing does not seem to bear very directly on the content of poetry. But when a poem can be read and read again, it is natural that the interest shifts from the rhythm to the meaning and the allusion. So the invention of photography has made the painter and the patron lose interest in the likeness and transfer it to some more formal pattern. Our whole sensibility has been re-created by such subtle shifts.

Science and the arts today are not as discordant as many people think. The difficulties which we all have as intelligent amateurs in following modern literature and music and painting are not unimportant. They are one sign of the lack of a broad and general language in our culture. The

difficulties which we have in understanding the basic ideas of modern science are signs of the same lack. Science and the arts shared the same language at the Restoration. They no longer seem to do so today. But the reason is that they share the same silence: they lack the same language. And it is the business of each of us to try to remake that one universal language which alone can unite art and science, and layman and scientist, in a common understanding.

CHAPTER 2

The Scientific Revolution and the Machine

1

THERE are three creative ideas which, each in its turn, have been central to science. They are the idea of order, the idea of causes, and the idea of chance. This book is concerned largely with these ideas. I begin at what is perhaps the most fugitive of the three, the idea of order.

None of these ideas is peculiar to science, and the idea of order least of all. They have applications to science; but all three are of course older than these applications. All are wider and deeper than the techniques in which science expresses them. They are common sense ideas; by which I mean that they are generalizations which we all make from our daily lives, and which we go on using to help us run our lives.

Unhappily, common sense has no recorded history. We often suppose indeed that it has no development, and that what we call common sense today has always been common sense to everybody – which certainly is not true.

Science records all this more conveniently. Science has a history in which the growth of these ideas can be traced plainly. More than this, we can in that history detect the moments of surpassing interest, when the common sense ideas were being formed afresh. Such a moment is now plain in the history of the seventeenth century. That age, which made Newton and which Newton made, was a climax and a fresh beginning in English science. And I go directly to Newton himself because nothing so reveals that age as the remarkable character of its greatest man.

2

No man of science, no man of thought has ever equalled the reputation of Isaac Newton. No other man has made so deep a mark on his time and on our world unless he has been a man of action, a Cromwell or a Napoleon. Like Cromwell’s and like Napoleon’s, Newton’s achievement was made possible by the coincidence, or better by the interplay of personality and opportunity. Each of these men, the man of thought as well as the men of action, entered history at a moment of social instability. Newton was

born during Cromwell's revolution in the troubled 1640s; he was eighteen at the Restoration in 1660; and he published the *Principia* during the intrigues which ended by bringing William of Orange to England in the revolution of 1688. These are the moments when the powerful mind or the forceful character feels the ferment of the times, when his thoughts quicken, and when he can inject into the uncertainties of others the creative ideas which will strengthen them with purpose. At such a moment the man who can direct others, in thought or in action, can remake the world.

Newton was such a personality. That complicated and nevertheless direct mind, that imperturbable engine of thought has stamped its mark on everything he did. The stamp is Newton's style, and the style and the content are one; both are projections of the same single-minded personality.

Science is not an impersonal construction. It is no less, and no more, personal than any other form of communicated thought. This book is not less scientific because my manner is personal, and I make no apology for it. Science searches the common experience of people; and it is made by people, and it has their style. The style of a great man marks not only his own work, but through it the work of others for generations. The style of Newton's work as much as the content dominated science for two centuries, and in that time shaped its manner and its matter. But style is not the monopoly of the great, nor is its appreciation a vintage reserved for experts. The schoolboy who can tell a neat proof from a dull one knows the style, and takes pleasure in it. Indeed, he finds it easier to appreciate the style of science than the style of Shakespeare.

I cannot hope to transmit that style, its feeling and its detail, at this remove. It cannot be bought, canned and dehydrated, on pages ten and eleven of somebody's history of world knowledge, either in the chapters on science or on Shakespeare. We all understand that Shakespeare, the whole Shakespeare, cannot be got out of any book but his own collected works. So if we want the whole Newton, the man and the manner, the large nose and the strong thumb-print of his style, then we must read the *Principia* and the *Opticks*. Only in this way will we get the personality and the movement of the work, the massive ease and the fluent assurance which the *Opticks* shares strikingly with *Antony and Cleopatra*.

But we need not therefore come to a dead stop on aesthetics. After all few of us value the style so highly that we cannot bear to read Balzac and Stendhal in translation, and even Flaubert and Proust. Few of us certainly would learn French only in order to preserve this aesthetic Puritanism. And in the same way we must be content with science in translation. The

science of an age, like its art or its music, has a style, yes. But it has a content and a structure too, larger than the work of any one man, within which the work of its men takes shape and meaning. Shakespeare was one of a group of playwrights, and he and they shared the expanding world of the Elizabethan voyagers and the patriotic adventures. Newton was one of the young discoveries of the Royal Society in its early days, in the restless setting which I have been describing. To know this does not of itself make us appreciate their achievement; and still less can such knowledge take the place of appreciation, in art or in science. But it does give us a context in which we can look beyond the single furrow of our own interest, into the whole fertile field of knowledge.

3

There never has been another moment in English history to equal the promise of that moment in the 1660s when the Royal Society was formally founded. And though it was less dramatic elsewhere, it was a high moment throughout Europe. The long tradition of astronomy in the seafaring nations was about to reach its climax, here with Newton, and in Holland with Huygens.

What was extraordinary about that moment at the Restoration? We all have a regard for Restoration times, and that in itself is something of a puzzle. What exactly commands the affection in which good King Charles II's day is held? Surely not the political and literary achievements which the history books quote. The most romantic Tory could not call Charles II a great king. Dryden was a great poet; nevertheless as a poet he does not rank with his predecessor Milton. As for the Restoration playwrights, by all means let us make the most of their hearty fun; but it hardly earns them a major place in English drama.

No, at bottom our regard for the period is sound because it rests on wider and less familiar achievements than these. They are scientific rather than literary achievements, but they are not specifically one or the other, any more than is Dryden's superb prose. They are the pioneer achievements of a liberal culture, and are part of a spontaneous widening of sympathy and interests throughout Europe. We can trace this even in the strange political conditions which made possible the recall of Charles II without bloodshed and with little vindictiveness after a long dictatorship born and perpetuated in blood and violence. And consider the circumstances in which, on Charles's return, the Royal Society was founded. Most of its leaders were professors of Puritan sympathies and some of them held chairs from which Cromwell had evicted the royalist

holders for them. Indeed, the mathematician John Wallis owed his eminence to his skill in applying science to Cromwell's military needs: he was a pioneer in breaking enemy cyphers, and this has remained the traditional wartime service of mathematicians. Charles II cannot have relished these men, and he had no overpowering interest in science. Yet Evelyn persuaded him to give his name to their new-fangled society; and the literary men competed with them for places in it.

There is a parallel in the position of Huygens in the Académie Royale des Sciences in Paris. Christian Huygens was born in Holland in 1629. His father and his grandfather were diplomats in the service of the House of Orange. The family was friendly with Descartes, who during Huygens's youth was an exile in Holland. In the 1660s Louis XIV was already putting pressure on the House of Orange and a little later he invaded Holland. Yet Huygens, a Dutchman, a Protestant, and a Cartesian, was called to France to help found the Académie Royale in 1666, and he remained its senior official into the 1680s, when anti-Protestant policy at last became too strong for him.

Huygens's distinction and leadership were as important to the Académie as were those of Newton, who was thirteen years younger, to the Royal Society soon after. He was not the equal of Newton as a scientist; he had not quite Newton's penetration and range in mathematics or in the principles of experiment. His temper was more that of the inventor and mechanic, and the English scientist most like him was Robert Hooke, curator of experiments and secretary to the Royal Society – a slightly fantastic character, whose dislike of Newton (and Newton's dislike of him) gave an air of extravagance to the scientific arguments of the times. Like Hooke, Huygens made fundamental improvements to the clock as an aid to astronomy. Huygens in effect invented the pendulum as a time-keeping mechanism; and Hooke invented the first passable escapement for the same purpose. The work of each of them, like Newton's and like every scientist's in that uprush of invention, covered an enormous field. Huygens discovered the rings of Saturn, and the formula for centrifugal force. He did important work in mechanics and optics, and one of his merits was that he made the young Leibnitz enthusiastic for these subjects.

I have remarked that these men were not scientists alone, nor was there a barrier between their interests and those of men of other skills. Artists, writers, and scientists shared their interests and their passions. In England the fellows of the Royal Society included Robert Boyle with the poet Denham, and Samuel Pepys with the mathematician Wallis; and Sir William Petty, and Edmund Waller, and John Aubrey. The Society was

down.

In putting it in this way, I have of course made a caricature of the answer. I have done so not to make fun of it but, on the contrary, in order to show that even in this extravagantly naïve form, the answer is not really childish. It would be childish only if it read ‘This apple falls down and not up because it is the nature of this apple at this instant to fall down.’ But this is not what Aristotle said. He said that the particular apple falls down now because it is the nature of all apples to fall down at all times. Simple as this notion may seem to us, it is in itself a bold and remarkable extension of the mind. The mere creation of a permanent class of apples, the mere generalization of the concept of apples, is an act of the first importance. Of course it is simple enough to make a class of identical objects such as pennies or the capital As in this book. But nature does not provide identical objects; on the contrary, these are always human creations. What nature provides is a tree full of apples which are all recognizably alike and yet are not identical: small apples and large ones, red ones and pale ones, apples with maggots and apples without. To make a statement about all these apples together, and about crab-apples, Orange Pippins, and Beauties of Bath, is the whole basis of reasoning.

This is so important that I must underline it. The action of putting things which are not identical into a group or class is so familiar that we forget how sweeping it is. The action depends on recognizing a set of things to be alike when they are not identical. We order them by what it is that we think they have in common, which means by something that we feel to be a likeness between them. Habit makes us think the likeness obvious; it seems to us obvious that all apples are somehow alike, or all trees, or all matter. Yet there are languages in the Pacific Islands in which every tree on the island has a name, but which have no word for tree. To these islanders, trees are not at all alike; on the contrary, what is important to them is that the trees are different. In the same islands men identify themselves with the totem of their clan, say with the parrot, and it seems to them plain that they are like parrots when to us the notion seems a mere artifice, and an outrageous one.

This ability to order things into likes and unlikes is, I think, the foundation of human thought. And it is a human ability; we trace and to some extent inject the likeness, which is by no means planted there by nature for all to see. Our very example of Newton’s apple shows this vividly. For Newton’s instant insight, as he himself told it, was precisely to see the likeness which no one else had seen between the fall of the apple and the swing of the moon in her orbit round the earth. The theory

of gravitation rests upon this; and familiar as the likeness now is to us, and obvious, it would have seemed merely fanciful to the Aristoteleans of the Middle Ages.

5

But, of course, the generalizations concealed within their answer did not stop at apples. What the Aristoteleans said was that the apple falls down and not up because it is the nature of earthy things always to fall down. They saw a likeness between all masses, and they used it to order the world around them into different categories of things, earthy, watery, airy, and fiery. It was a far-reaching theory, and it was applied to the body and the mind as well as to dead matter. But what interests us now is the kind of structure which it gave to the universe. In that structure, earthy things belonged to the earth; their natural resting place was the centre of the earth; and they fell to earth in their longing for that. What buoyed the universe and kept it from finding the state of dead rest in its natural centres was the tug of war between the elements, earthy matter carried off by the action of fire, water swept up in a rush of air. The universe lived by the tension between the elements, all at cross purposes because all in search of their different centres. It is a lively idea, and it is an order of nature based upon recognizable likes and unlikes. Yet to us it is now only a neat fancy; the likeness on which it is built seems to us to lie in inessentials; and very bluntly it seems to us not to understand at all how the world works.

The system of the Middle Ages, which had been taken from Aristotle, differs in two outstanding ways from anything that we expect of a physical system. First, it has quite different notions about matter: notions which are different in kind from ours. There are within that picture springs of action of a kind we would not dream of projecting into matter: springs of human action, where we see only the impersonal turning of a machine. Earth, water, air, and fire have natures which are at bottom human nature, and were recognized by those who made this picture as parts of human nature. What drives them is a kind of will, a mindless will perhaps, but still an obstinate animal will. Masses as it were wanted to find rest at the centre of the earth; air wanted to stream up. Abstractly Aristotle might hold that, given these natures of the elements, everything else goes on of itself. But in fact it was not meant as a mechanism or worked out as one. It grew from a view of nature as essentially animal, wilful, and alive.

Secondly, there was in the whole conception a kind of order which

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