The Structure of the Matter of the Created World as a Manifestation of the Wisdom and Goodness of God

Address to the Plenary Session and to the Study Week on the Subject 'The Question of Oligoelements in Plant and Animal Life'

The Pope observes that scientists are dedicated to the study of natural phenomena and that the 'created world is a manifestation of the wisdom and goodness of God'. For this reason, men and women of science have the mission to be the 'discoverers of the intentions of God'. He refers to the immense advances in science in modern times and regrets the historical separation of philosophy and science, calling for a productive union of the two, not least to achieve an 'all-embracing view of the visible world'.

As we bid you welcome in this house, whose doors have always been opened wide to those who cultivate the arts and sciences, we desire also to express to Your Excellencies, Members of our Academy, our lively satisfaction.

Your life, consecrated as is to the study of natural phenomena, enables you to observe every day more closely, and to interpret, the wonders which the Most High has inscribed on the reality of things. In very truth, the created world is a manifestation of the wisdom and goodness of God, for all things have received their existence from Him and reflect His grandeur. Each of them is, as it were, one of His words, and bears the mark of what we might call the fundamental alphabet, namely those natural and universal laws derived from yet higher laws and harmonies, which the labour of thought strives to discover in all their amplitude and their absolute character.

Created things are words of truth. In themselves, in their being, there is neither contradiction nor confusion. Rather, they always cohere one with the other. Sometimes they are difficult to understand because of their depth, but always, when clearly known, they are seen to be in

conformity with the superior exigencies of reason. Nature opens up before you like a mysterious but astonishing book, which must be turned page by page and read in an orderly manner, with the aim in mind of progressing ceaselessly. In this manner, every forward step is a continuation of the preceding ones, corrects them, and climbs continually toward the light of a deeper understanding. The mission confided to you, therefore, ranks among the most noble, for you should be, in a sense, the discoverers of the intentions of God. It pertains you to interpret the book of nature, to describe its contents, and to draw the consequences therefrom for the good of all.
First of all, you are the interpreters of the book of nature. It is, then, necessary that you fix your gaze on each line, and be ever most careful not to pass over any detail. Set aside all personal bias, and accommodate yourselves with docility to every indication of truth which comes to light.
We are aware of the exceptional importance of the epoch through which science is passing at this time, an importance which not all succeed in appreciating. In fact, there exist, in regard to scientific problems, three different attitudes. Some, and they are the majority, are content to admire the extraordinary results obtained in the technical realm and, it would seem, believe that these results constitute the sole, or a least the principal, aim pursued by science.
Others, better informed, are capable of appreciating the method and efforts required by scientific research. They can thus follow and understand its remarkable advances, its successes and checks. They observe with interest the ceaseless perfecting of mathematical methods, of experimental procedure, of instrumentation. They follow passionately the working out of hypotheses, the establishment of conclusions, the intellectual labour of harmonising data, schematically modifying previous considerations, formulating new theories that will be subjected to verification. These multiple aspects are well understood by all those who, for various motives, interest themselves in the work of scientists.
As for the most essential problems of scientific knowledge, or those whose amplitude embraces its entire realm, the minds which perceive them are, it seems to us, relatively few in number, and we rejoice at the thought that you are among them. Has not science arrived at the point of demanding that our vision should penetrate readily the most profound realities and rise to a complete and harmonious view of these in their wholeness?

1. A little more than a century and a half ago, by starting from rational bases, the first hypotheses were formulated concerning the discontinuous structure of matter and the existence of very minute particles, which were considered the final constituents of all bodies. From that time until our day, molecules have been counted, weighed and analysed. Then the atom, at first considered indivisible, was split into its elements. It was examined and attacked in its innermost structure. The elementary electrical charge was determined, as well as the mass of the proton. The neutron, the mesons, the positron and many other elementary particles were identified and their characteristics determined. Means were found to guide these particles, to accelerate them, to shoot them into atomic nuclei. But it was especially by utilising neutrons that man succeeded in producing artificial radioactivity, nuclear fission, the transformation of one element into other elements, the production of enormous quantities of energy.
Theories and ingenious representations of the world have appeared; new mathematical methods

and new geometries have been created. We can only mention here the special theory of relativity and the general theory of relativity, quanta, wave mechanics, quantum mechanics, recent ideas on the nature of nuclear forces, theories on the origin of cosmic rays, hypotheses concerning the source of stellar energy.
All this permits us to glimpse the depths into which science has moved, and one readily realises the problems of an intellectual nature which will arise. It should be taken into consideration, moreover, that, while the bold band of conquerors ever opens new breaches in the citadel of nature, the rest of the army is spread over numberless other fields of knowledge: and this is the point of view of extension, which must be added to that of depth. One would wish to be able, like the bold climber arriving at the summit of the mountain, to take in the entire spread of the panorama with a single glance.
If it were possible for us, we should like to show you the most advanced position in the various sectors of science, so that there might appear before your eyes a general view of the present situation.
See how astronomy, by means of instruments recently placed at its service, succeeds in unveiling entirely new mysteries in the heavens and, with the help of the physical sciences, has set out on the road which will perhaps lead it to elucidate the source of stellar energy. See how geology determines the absolute age of rocks by means of radioactivity and isotopic correlations: a beginning has even been made towards determining the age of the earth!
In mineralogy, crystalline structures are yielding up their secrets to powerful analyses using radiations of very short wave-length. Inorganic and organic chemistry is solving the complex problems of the structure of macromolecules: it is successfully building huge molecular chains and, by the resultant applications, is transforming whole sectors of industry. Radio technique has succeeded in producing electromagnetic waves which ap-proach the limits of luminous radiation of greatest wave-length. The earth is delved into so that its hidden treasures may be discovered, the highest strata of the atmosphere are being explored, genetics is bringing to light, in certain particular cellular complexes, new aspects of the power of life.
Physiology and biology, starting from bases achieved by chemistry, physical chemistry and physics, daily encounter unsuspected marvels and daily interpret, explain, forecast new facts and bring them to realisation. The domain of the virus is giving way to the assault of the electronic microscope and of the electronic diffraction technique. The mass spectrograph, Geiger counters, radioactive isotopes, all such instruments facilitate the progress of science as it faces the greatest enigma of all visible creation: namely, the problem of life.
In synthesising all this knowledge it is philosophy which, with its broad concepts, states precisely the distinctive traits of vital factors, the necessary character of the underlying principle of unification, the internal source of action, of growth, of multiplication, the true unity of the living being. It shows, too, what matter, in some of its fundamental aspects, must be in order that there may be realised in the living being the characteristic properties which constitute it.
These are, without doubt, the domains that will give most work to the science of tomorrow.

2. But the feeling of elation engendered in one’s soul by results like these is dampened by an

impression of confusion and anguish existing among those who, with a sense of their responsibility, are following the unfolding of the facts. This anguish and confusion are to be understood in the most elevated sense, as sign of an aspiration toward an ever greater clearness in perspectives. For the triumphs of science are themselves at the origin of the two requirements to which we alluded above.

a) The first task is to penetrate the intimate structure of material beings and to consider the problems connected with the substantial foundation of their being and of their action. The question then arises: 'Can experimental science solve these problems by itself? Do they belong to its domain? Do they come within the field where its research methods can be applied?'. One must answer in the negative. The method of science is to take as its starting point sensations, which are external by their very nature. Through them, by the process of intelligence, it descends ever more deeply into the hidden recesses of things. But it must halt at a certain point, when questions arise which cannot be settled by means of sense observation.
When the scientist is interpreting experimental data and applying himself to explain phenomena that belong to material nature as such, he needs a light which proceeds in the inverse direction, from the absolute to the relative, from the necessary to the contingent; a light which is capable of revealing to him the truth which science is unable to attain by its own methods. This light is philosophy, namely, the science of general laws which apply to all being and therefore are applicable in the domain of the natural sciences, above and beyond the laws discerned empirically.

b) The second requirement springs from the very nature of the human soul, which seeks a coherent and unified view of truth. If one is satisfied with a juxtaposition of the various subjects of study and their ramifications, as in a kind of mosaic, one gets an anatomical composition of knowledge from which life seems to have departed. Man demands that a breath of living unity enliven the knowledge acquired. It is in this way that science becomes fruitful and culture begets an organic doctrine.
This raises a second question: 'Can science with the means which are characteristic of it, effect this universal synthesis of thought? And in any case, since knowledge is split up into innumerable sectors, which one, out of so many sciences, is the one capable of realising this synthesis?'. Here again we believe that the nature of science will not allow it to accomplish so universal a synthesis. This synthesis requires a solid and very deep foundation, from which it derives its unity and which serves as a basis for the most general truths. The various parts of the edifice thus unified must find in that foundation the elements that make up their essence. A superior force is required for this: unifying by its universality, clear in its depth, solid by its character of absoluteness, efficacious by its necessity. Once again that force is philosophy.

3. Unfortunately, for some time past, science and philosophy have been separated. It would be difficult to establish the causes and responsibilities for a fact so detrimental. Certainly the cause of the separation must not be sought in the nature of these two ways, each of which can lead to truth.

Rather, it must be sought in historical contingencies and in persons who did not always possess the necessary goodwill and competence.
At one time men of science thought that natural philosophy was a useless weight, and they refused to allow themselves to be guided by it. On the other hand, philosophers ceased to follow the progress of science, and they halted in certain formal positions which they could have abandoned. But when, as we have shown, there arose the inevitable necessity for a serious work of interpretation, as also for the elaboration of a unifying synthesis, scientists fell under the influence of the philosophies which the circumstances of the time placed at their disposal. Many of them, perhaps, were not even clearly aware that their scientific investigations were being influenced by particular philosophical trends.
Thus, for example, mechanistic thought guided for a long time the scientific interpretations of the phenomena observed. Those who followed that philosophical trend believed that every natural phenomenon was reducible to an ensemble of physical, chemical and mechanical forces, in which change and action were solely the result of a different disposition of particles in space and of the forces or displacements, to which each of them was subject. It followed that, in theory, one could foresee with certainty any future effect whatsoever, provided one knew beforehand the geometrical and mechanical data. According to that doctrine, the world was merely an enormous machine, composed of an innumerable series of other machines joined together.
Further progress in experimental research showed, however, the inexactitude of those hypotheses. Mechanics, deduced from the facts of the macrocosm, cannot explain or interpret all the phenomena of the microcosm: other elements come into play which defy any explanation of a mechanistic nature.
Take, for example, the history of the theories of the structure of the atom. At the beginning they were based essentially on a mechanistic interpretation, which represented the atom as a minute planetary system, made up of electrons circling around the nucleus according to laws entirely analogous with those of astronomy. Quantum theory later imposed a complete revision of these concepts and produced interpretations which were ingenious, certainly, but also unquestionably strange. In effect, there was conceived a type of atom which, without eliminating the mechanistic aspect, made the quantum aspect more prominent.
The mode of behaviour of the corpuscles was thus explained in different ways: electrons which, although revolving about a nucleus, did not radiate energy when, according to the laws of electrodynamics, they should have been radiating it; orbits which could not change continuously, but only in jumps; the emission of energy which occurred only when the electron passed from one quantum state to another, producing photons of a definite frequency determined by the differences in energy levels.
These hypotheses, as points of departure, were later stated precisely after the birth of wave mechanics, which fitted them into a more general and coherent mathematical and intellectual framework from which the traditional mechanistic ideas have vanished.
Then, spontaneously, the question arises: ‘How can it be that the macroscopic world, although composed of elements which all belong to the microscopic world, nevertheless obeys different laws?’ Science answers, first of all, with the following observation: when the number of elements in

question is very great (billions upon billions of particles), then the statistical laws deriving from the behaviour of these different elements taken in their entirety are considered to hold strictly in the world directly observable by us.
But if the statistical method is satisfactory for the purposes of science, it reveals also how false were certain philosophical hypotheses which were limited to external evidence perceptible to the senses and then extended arbitrarily to the entire cosmos.
Confirmation of this is found in the theories of modern nuclear physics. In reality, the forces which hold together the nuclei are different from those that are discovered when studying the macrocosm. To understand them it is also necessary to change the customary manner of conceiving the corpuscular particle, the wave, the exact value of energy and the rigorously precise localisation of a corpuscle, and, indeed, the foreseeable character of a future event.
The failure of the mechanistic theory has led thinkers to hypotheses entirely different – characterised rather by a kind of scientific idealism – wherein the consideration of the active subject performs the principle role. For example, quantum mechanics and its fundamental principle of indeterminism with the challenge to the principle of causality which it supposes, appear as scientific hypotheses influenced by currents of philosophical thought.
But because these hypotheses themselves do not satisfy the desire for complete clarity, many illustrious thinkers have been brought to scepticism when confronted with the problems of the philosophy of science. These claim that it is necessary to be satisfied with the simple verifying of facts and striving to have these included in formal presentations – synthetic and simple – in order to foresee the possible developments of a physical system from a given initial state.
This state of mind results in the abandonment of conceptual introspection and in the loss of all hope of producing grand universal syntheses. We do not, however, believe that such pessimism is justified. We rather think that the natural sciences, in permanent contact with a philosophy of critical realism, such as was always that of the *philosophia perennis* as exemplified by the most eminent of its representatives, can arrive at an all-embracing view of the visible world which would, to some extent, satisfy the quest and the ardent desire for truth.
But it is necessary to emphasise another point. If science has the duty to strive for coherence and to seek inspiration from sound philosophy, philosophy itself should never attempt to define truths which are drawn solely from observation and from the use of scientific methods. An infinite variety of entities and laws of matter is possible. Only observation or experiment, understood in their very broadest sense, can point out which among these the Creator, in fact, desired to make into reality.
Authorised interpreters of nature, may you also be the teachers who explain to their brothers the wonders which are unfolded in the universe, and which you, better than others, see assembled as in a single book. Indeed, the majority of men can scarcely devote themselves to the contemplation of nature. They deduce from the facts they perceive only superficial impressions. Become, you who interpret creation, teachers eager to reveal its beauty, its power and its perfection so that they may be enjoyed by others.
Teach others to behold, to understand and to love the created world so that the admiration of splendours so sublime may cause the knee to bend and invite the minds of men to adoration.
Never betray these aspirations, this trust. Woe to them who make use of falsely taught sciences to

make men leave the right path! They are likened to stones maliciously placed in the path of the human race. They are the obstacles on which men stumble in their search for truth.

You have in your hands a powerful instrument with which to do good. Take into account the unutterable happiness that you procure for others when you disclose to them the mysteries of nature and bring them to understand its harmonious secrets. The hearts and the gaze of those who listen to you are, as it were, hanging on your every word, ready to chant a hymn of praise and thanksgiving.