WERNER HEISENBERG'S CONCEPTION OF SCIENCE AS AN AVENUE TO RELIGIOUS UNDERSTANDING: THE PART AND THE WHOLE

BY

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A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

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ABSTRACT

This thesis is concerned with physicist Werner Heisenberg's conception of science as an avenue to religious understanding, in the same manner that art and ethical action exist as such avenues, and only in connection with those other avenues; here, religious understanding is defined as understanding of self/soul. To support this, it was necessary to demonstrate Heisenberg's perception of a correspondence between the methods and aims of science, especially modern and 20th-century physics, and those of art and ethical action; it was also essential to show the interconnectedness of those avenues as they occur in a multi-faceted and multi-levelled framework. This was achieved by establishing his grounding in the Platonic tradition, as it is found in both Christian and non-Christian thinkers, and moving through those realms of art, science and ethics: given his conception of the soul as the image of the "central order", and his conviction that all understanding is simply re-cognition of the structures of our inner core, the distinct avenues and their respective concepts and languages are perceived by him to move and work together to uncover those inner structures. The results of this study confirm the argument that Heisenberg conceives science to be an avenue to religious understanding, in connection with the other avenues.

INTRODUCTION

> It is evident that the passage from science to philosophy has given rise to a great many misunderstandings. But I do not believe that it would be useful to try to separate the two fields absolutely and say: Here is the man of science, there the philosopher. On the contrary, I believe that it is useful to let the man of science talk philosophy, and the philosopher sometimes science, even at the risk of creating new misunderstandings. The result can be so useful that it is worth running the risk.[1]
>
> Werner Heisenberg

As a thoughtful scientist, Werner Heisenberg is unable to separate the questions of physics and philosophy. Of course, philosophy and science have always had a close relationship, although that relationship has sagged somewhat in the last hundred years or so. Heisenberg's own work was instrumental in the serious re-introduction of philosophy into science, especially ontological and epistemological questions; in retrospect, it appears impossible that any work in the quantum field could have been accomplished without philosophical re-evaluation, and this no doubt accounts for Heisenberg's life-long interest in the philosophical aspects of science. Anyone familiar with quantum theory, or science in general, could not argue against the need therein for philosophical deliberation.

However, although contemporary philosophy tends to shy away from any connection with religion, it would appear that Heisenberg finds them intimately connected; in fact, he understands philosophy as simply one aspect of the total

religious enterprise. This suggests, of course, a profound relation between science and religion. In this age, such a relationship would surprise most people, since it is often assumed that religion and science, much more so than philosophy and science, have nothing to say to each other. Of course, one may be a scientist as well as having deep religious life, as was, for example, the great Max Planck. However, Heisenberg makes an important distinction here: "Planck considers religion and science compatible because, in his view, they refer to quite different facets of reality... Science is, so to speak, the manner in which we confront, in which we argue about, the objective side of reality. Religious faith, on the other hand, is the expression of the subjective decisions that help us choose the standards by which we propose to act and live."[2] This is the understanding of not only Planck, says Heisenberg, but for that whole generation: science and religion are infinitely separated, connecting at no point.

However, since Heisenberg adds, in his usual understated manner, that he himself does not feel altogether happy about this separation, and others have deemed him "the most metaphysical of modern scientists,"[3] it is not surprising that for him, science and religion are united in the most profound ways. In fact, it will be argued here that science, particularly quantum physics, is for Heisenberg a religious enterprise of the highest order, though only so when

understood as a part of the whole. By this, it is meant that science by itself cannot function as an avenue to religious understanding; it must have recourse to, and work in conjunction with, the insights given by other avenues that aim at an understanding of "man's relatedness to the central order."[4] The lesson of the last two centuries, where science and technology became a 'god unto itself', taught Heisenberg the evil of the elevation of a fragmentary order to an absolute one. The revolution of quantum physics earlier this century has returned to science an awareness of its limitations and reliance on ideas that are deeply religious in nature; far from a degradation of science through these restraints and dependencies, its full power as an avenue of religious understanding is revealed. Again, though, it cannot be seen as such in isolation from the other avenues of religious understanding; hence, the demonstration of Heisenberg's perception of science in this regard necessitates its situation in the context of his total religious understanding.

Thus, this demonstration will be neither uncomplicated, nor brief. To begin, it will be necessary to uncover the physicist's definition and understanding of religion, which is rooted in the ancient Greek tradition, and continues in the Christian. Although Heisenberg is noted primarily as a man of science, who wrote few specific discussions of religion, his written work on science, and related topics, contains a great

deal of clues to this religious understanding, one that is most satisfactory for our purposes. The personal importance to Heisenberg of this understanding must also be made clear (chapter one). In light of his definition, what strikes most clearly is that Heisenberg does not conceive of 'religion' as a noun; it is a profound and ancient process in which many activities participate. In this connection, Heisenberg's understanding of art will be prominently highlighted, first of all because it bears closely on our discussion of science in that same capacity, and secondly, because it reaches levels in the soul where science cannot go, yet helps to set forth the framework in which science can be understood as valuable. However, although the value of science depends upon the deeper insights of art, Heisenberg notes that at the present time, the serious recovery of art can occur only through a deep understanding of science, particularly a physics which has recovered the guide of the central order (chapter two). A portion will be devoted to Heisenberg's understanding of a mathematical science so guided, as it has manifested itself in the Western tradition, as well as his understanding of that period of scientific 'immodesty', where science forgets its limitations and connection to the whole. The more important focus will be his perception of the re-awakening of science, occurring when science, particularly quantum physics, finds itself in the same position as religion, that is, dealing with a reality removed from daily experience. Here, Heisenberg

discovers that science must come to grips with the same strengths and limitations of human knowledge which all avenues of religious understanding must acknowledge, if they are guided by the compass of the central order; if anything, science makes this realization more clear. Yet, that which science can say to have understood, and the way in it understands it, re-turns science to its original role as an avenue to absolute discovery, and a springboard to further understanding (chapter three, parts 1 & 2).

Finally, this further, and deepest, of understanding is impossible without the recognition that science and religion are both lived enterprises; understanding, says Heisenberg, comes only through faith, and faith is the decision to act, with a willingness to stake one's life on that action. As he discovered through his scientific work, the Ideas are only actualized through a connection with the rest of the world; so too are the Ideas within us only actualized through contact with the rest of the world. He argues that scientists, including himself, must use the understanding gained from their work, an understanding which Heisenberg sees as the crucial foundation for renewed spirituality in the West, in connection with understanding from the other avenues, to act, and in that action, arrive at a true understanding of ourselves and our relation to the central order (chapter four).

By no means does this investigation of Heisenberg's thought claim to be a critical one. For example, not once are objections to the Copenhagen Interpretation introduced, though there do exist such objections. Neither has there been an attempt to read him through the context of twentieth-century history and trends of thought. The concern cannot yet be the way in which we should see Heisenberg. Rather, because comparatively little study has been devoted to the physicist and his ideas, the concern must for the moment remain what it is that Heisenberg sees, as far as this can be achieved. Admittedly, this work cannot claim to be a completely impartial study of his thought. In some places, I have consciously sought to expand, through other sources, points which I believe Heisenberg either moves through too rapidly, or simply does not make clear enough; obviously, my choice of sources is affected by my own perception of his thought. As Heisenberg might put it, I am both spectator and actor in this particular drama. Nonetheless, Heisenberg writes to be understood; this is abundantly clear. Thus, in attempting to follow as closely as possible the forms and content of Heisenberg's thought, I am confident that his ideas have been unfolded here in the direction faithful to his original conceptions.

Yet, whatever the problems involved in an approach to Heisenberg's thought, there is little doubt that it must be approached. It is intriguing that an understanding of his

thought should still remain an issue to be addressed, given that his own works, on almost any topic, are so clearly born out of his immense vision. However, that he has often been misunderstood, or worse, ignored, suggests the necessity of re-answering this question, if not re-posing it. What does Heisenberg see? It is an important question, simply because his answer is so remarkable. His vision of an order of great and intricate beauty in the universe and in ourselves is so remarkable, in fact, that one can easily be swept along with it. Perhaps, before the inevitable (and crucial) stage of intense and informed criticism, one should allow oneself to be caught up in this vision, to 'see, feel, and believe' in that beautiful order of the one, the good and the true. At the very least, even if one retreats from the vision, one will have come to a better understanding of Heisenberg, an indispensable foundation for further critical dialogue with the physicist. At the most, one may learn something about the nature of ourselves and the universe. Whatever the reaction to his vision, there can little disagreement that he says a great deal that is worthy of our serious consideration. Hence, for the time being, our task is simply to re-present that vision, which is, of course, best illustrated in Heisenberg's own works.

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As will soon be discovered, Heisenberg is adamant that content is meaningless without form; that the content of this

particular work be unfolded to the greatest of its potential, its more formal aspects will be guided by Kate L. Turabin's A Manual for Writers of Term Papers, Theses, and Dissertations (3d ed.; Chicago: University of Chicago Press, 1967). Of course, form can be equally empty without significant content; in this case, the reader remains the authority.

NOTES TO INTRODUCTION

1.Heisenberg, "Planck's Discovery and the Philosophical Problems of Atomic Physics," in On Modern Physics, trans. by Goodman and Binns (New York: Clarkson N. Potter, 1961), p.32.

2.Heisenberg, Physics and Beyond, trans. by Arnold J. Pomerans (New York: Harper and Row, 1971), p.83; Heisenberg, Der Teil und Das Ganze (München: R. Piper & Co Verlag, 1971), pp. 116,117: "Ich vermute... daß für Planck Religion und Naturwissenschaft deswegen vereinbar sind, weil sie, wie er voraussetzt, sich auf ganz verschiedene Bereiche der Wirklichkeit beziehen...Die Naturwissenschaft ist gewissermaßen die Art, wie wir der objektiven Seite der Wirklichkeit gegenübertreten, wie wir uns mit ihr auseinandersetzen. Der religiöse Glaube ist umgekehrt der Ausdruck einer subjektiven Entscheidung, mit der wir für uns die Werte setzen, nach denen wir unser Handeln im Leben richten.»

3.Patrick A. Heelan, Quantum Physics and Objectivity (The Hague: Martinus Nifhoff, 1965), p. x.

4.Heisenberg, Physics and Beyond, p. 214; Heisenberg, Der Teil und das Ganze, p. 291: "...die Beziehungen der Menschen zur zentralen Ordnung der Welt..."

CHAPTER ONE: RELIGION

In one of his few specific discussions of religion, Heisenberg states that the various religious traditions are merely different formulations of one common concern: the human "relatedness to the central order", or the 'one', as he refers to it.[1] Of course, he does not wish to belittle the differences, which he understands as demonstrating the profound distinctions in the awareness of different human groups; in fact, he would say that exchange between the different groups and ideas can deepen the understanding of the human relationship to the central order. Rather, he is simply trying, in this rather general definition, to encompass a profound, and universal, direction of humanity; he believes that, whatever the instrument for determining direction, be it happiness, the will of God, or the meaning of life, at base, the direction is an understanding of our connection to that central order. One may think of the different ways of reaching point A from point B: it is possible to use a compass, the stars, or a map, but the goal is still point A: at the deepest level, a harmonious relationship with the central order is the purpose of each. Religion, for Heisenberg, includes all enterprises that hold this as their aim; hence, the term 'religion' from here on will refer to this inclusive understanding, rather than to 'organized religion.'

Heisenberg insists that we, in the West, owe this definition of religion to the ancient Greeks, noting that it

was they who first posed questions of principle, and not merely as an intellectual game: the question of ultimate source was closely related to the question of actions. For example, Plato held the Ideas to be the ordering principle of the universe, and demanded that our actions be guided by aspiration to these Ideas; we will return to this issue of action. Yet, however the relation of the "one" and the "many" was approached, it was an intense and serious business for the ancient Greeks, and this is their great legacy to us. As Heisenberg notes, at the heart of organized religion, art, and science lies the same attitude of mind, initiated by the ancient Greeks, and further developed in the great fusion of that profound Greek spirit of enquiry and Christian piety: "our whole cultural life, our actions, our thoughts and our feelings, are steeped in the spiritual roots of the West."[2] Yet, this gift of the connection between questions of principle and action, and the answers there given, is not a gift which we can accept or reject arbitrarily; it is an intimate part of ourselves, which is fruitful only if recognized and deeply respected. "We wish that, despite all outer confusion, our youth will grow up in the spiritual climate of the West, and so draw upon those sources of vitality which have sustained our continent for more than two thousand years."[3]

His trust in these Western spiritual roots is sharply illustrated in a conversation held between himself and a

friend as they were walking home after an air raid on Berlin in 1943. Moving between rows of burning houses, avoiding flaming debris and unexploded bombs on the streets, Heisenberg still sees hope in the people that have given themselves, though many unwillingly, to the Nazis. Speaking of the search for the absolute, he speculates that "Perhaps we Germans, of all people have a special part to play in this area precisely because the absolute exerts so strange a fascination on us."[4] However, it is partly that German fascination with the absolute that Heisenberg believes responsible for the chaos of Nazi Germany, especially coupled with an impatience to realize that absolute. The physicist assumes that Germans, and this is easily extended to humanity as a whole, often tend to think of logic and the facts of nature as a straitjacket, which, when stripped away, reveals the absolute: "We think that freedom lies only when we can tear this jacket off - in fantasy and dreams, in the intoxication of surrender to some sort of utopia."[5] This is not the way, insists Heisenberg, and neither is the pragmatism that has so often raised its head in history, although that approach has often proven successful in technology, economics and politics. Yet, concerning the realization of the absolute,

> ...in science and art those philosophical principles which the ancient Greeks developed to such magnificent effect have proved more successful still. If Germany has made scientific or artistic contributions that have changed the world - we have only to think of Hegel and Marx, of Planck and Einstein, of Beethoven and Schubert - then it was thanks to this love of the absolute, thanks

to the pursuit of principles to their ultimate consequences.[6]

The sources of vitality to which Heisenberg is drawn, and those which he believes have shaped the best of Western culture, are of course the Platonic, including those in the Christian tradition. And although it may be stated at the outset that Heisenberg himself rarely strays too far from the answers given by the Platonic/Christian tradition, it is significant that the physicist does not strictly remain with those resolutions; for example, although Plato's conception of symmetries as the smallest units of matter is an important one for Heisenberg, he states unequivocally that those "symmetries were not yet the correct ones."[7] Discussion and discovery has not ended with Plato, yet Heisenberg's confidence in that tradition is not undermined by the new knowledge accrued since then. "Clarity," he quotes Bohr, "is gained through fullness."[8] It would seem that his trust in the Platonic tradition stems from the fact that the tradition itself is rooted in dialogue; that is, the tradition is a great human enterprise, whereby all must become involved in the search for ultimates. No one is exempt from the search, and silence or deliberate reservation on the part of any individual might spell doom for the whole undertaking. This latter is not merely a theatrical statement. As shall be seen much more clearly later, understanding can truly only occur through the interplay between ourselves and the world, both the world of

nature and the world of humanity; hence, that interplay is considered by Heisenberg essential. For example, noting the fresh light thrown on philosophical, ethical, and political problems by modern atomic physics, the physicist hopes that his book, Der Teil und das Ganze (itself containing "the only genuine Platonic dialogues of recent times that I know of" - C.F. von Weizsäcker[9]), "may help to draw the largest possible circle of people into this vital discussion."[10]

This hope is not surprising, though, since he constantly emphasizes the inter-active character of all aspects of humanity. He maintains that "man can only develop his mental and spiritual powers in relation to a human society,"[11] and he considers this especially true of science-oriented intellectual powers: in the preface to the above book, he reminds the reader that "science is made by men, a self-evident fact that is far too often forgotten."[12] Heisenberg is well aware, from personal experience, that science does not progress in clean, easy, logical steps, where results and their consequences are immediately clear. He notes that, though science may be based on experiments, "Its results are attained through talks among those who work in it and who consult one another about their interpretation of these experiments...science is rooted in conversations."[13] The creative processes of science depend not on the individual, but on the cooperation and dialogue of many.

It is only logical that Heisenberg should extend this conception further, and thus we see him focus on religion as the spiritual form of the community, rather than of the individual, and in many ways he considers religion itself to be an on-going dialogic process of the community. Certainly, there is no question here that dialogue seems to be a key factor: "Man's ability to reach beyond the realm of the purely sensory and appreciate that which is beyond, are based on his being part of a community of thinking and speaking beings."[14] The recognition of wider interrelations cannot be had outside a community, without the genuine give and take of thought in a sincere search for the meaningful connection of the whole. For example, it is through Heisenberg's many dialogue partners that he realizes the connections between science, art and ethics, that they are each born out of the questions of principle and action. Again, it is not only dialogue between contemporaries, but a continuing dialogue with the figures of tradition. Heisenberg's own dialogue with Plato constitutes one over a great distance of time; in addition, Kant, Kepler, Goethe are all dialogue partners. Of course, Heisenberg does not compartmentalize his dialogue partners; it is significant to note that those scientific partners, Bohr, Pauli, von Weizsäcker, Einstein, Planck, etc. are also his religious dialogue partners. The dialogue is possible because of the many points of interaction: their thought is unavoidably rooted in the Western tradition, and share those traditional

concepts which "form our way of thinking about the problems and determining the questions."[15]

Although Heisenberg's own roots are Catholic, and he is very aware of the orthodoxy there that once condemned Galileo, he does understand that facet of Christianity as open to dialogue. For example, in his festival oration for Munich's 800th anniversary, he perceives the essential nature of the city to be based in Catholicism: "Assuredly the foundation of this multifarious essence continues to be the conservative, Catholic spirit of its native inhabitants."[16] Yet, Heisenberg believes that it is because of, rather than in spite of, this foundation that Munich can boast of a tremendous intellectual life, through its toleration and receptivity of the novel, and its own sense of spiritual adventure, an adventure grounded in the wisdom that Catholicism embraces.[17] As he says of the local, Catholic Bavarians, and their relationship with the "incomers": "a great deal of good comes of trying, despite differences which seem insuperable, to live together somehow with goodwill, and perhaps through just such a collaboration of highly dissimilar forces to bring something new into existence."[18] Without doubt this characterizes Heisenberg's own Catholic relationship with other religions beyond Christianity, whose insights he occasionally includes in his writings; despite all the profound differences, he believes that each is concerned with the human relationship to the central order, and thus

that there exist points of genuine interaction. However, for all his efforts in this direction, it is quite clear that he is most comfortable in the Western tradition. Nonetheless, he would never discount the insights and dialogic promise of other traditions, for he learned from Bohr that each religion uncovers at least one facet of the total truth.

Furthermore, the medium of dialogue need not exclusively be words. For example, the development of music is also a form of dialogue; it was suggested to a young, attentive Heisenberg that "Perhaps men like Bach or Mozart are kings of music only because, for two long centuries, they have offered so many lesser musicians the chance of re-interpreting their thoughts with love and a conscientious attention to detail. And even the audience participates in this careful work as it hears the message of the great musicians."[19] In Physics and Beyond (Der Teil und das Ganze), music is especially highlighted as that which speaks meaningfully to us, and we to it. In like manner, Heisenberg believes that all the arts evolve in this dialogic way, an evolution characterized by "careful work, attention to detail...[and] utter devotion."[20] As in fruitful scientific dialogue, which leads to an important scientific discovery, or religious dialogue, which may lead to wisdom (or vice versa), musical dialogue has the power to create important works of art:

> ...quite suddenly, this slow process, in which general historical developments introduce changes in the contents of a particular discipline, opens up new possibilities, quite unexpected contents. Talented men feel an almost

> magical attraction for the process of growth they can sense at work here, and so it happens that a relatively small region of the world will produce major works of art...[21]

Given that our tradition stems from a question of our relation to the central order, a major work of art is considered by Heisenberg that which realizes something new and significant about that relation. The physicist is adamant that religion, as we have spoken of it above, "is of decisive importance for art."[22] It is that concern for the human relatedness to the central order which spurs the artistic being to create, and thus we are given a work like Beethoven's D Major Serenade, which "brims over with vital force and joy; faith in the central order keeps casting out faintheartedness and weariness."[23] In fact, of all the ways that humans express this relation, Heisenberg is convinced that the way of art is the most clear, and the most immediate: "A glance into the history of the most diverse cultures teaches us that we can infer most directly the spiritual pattern of an earlier period from the works of art that survive, even when the religious doctrine in which the spiritual pattern was formulated is scarcely known to us."[24] As a talented musician, who was given a real option between a scientific and musical profession, it is little wonder that Heisenberg should feel music, especially of all the expressions of art, to exist as an important avenue to religious understanding, which is a different thing altogether than an understanding of religion.

Yet, that he did choose a scientific career over a musical one gives a few meaningful insights into the thought of the physicist. First of all, he took seriously the idea that the individual's decisions are important not only to himself but to the whole of humanity; thus, eager to participate in that great dialogue concerned with a clearer understanding of the human relation to the One, it was vital that he know where best he might contribute. For all the power that music held for him, it was also obvious to him that "in recent years music has lost much of its earlier force."[25] A young Heisenberg points out that music in the past few centuries has explored this relation in depth: the seventeenth century saw music steeped in the religious way of life, the eighteenth century conquered the world of individual emotions, while the nineteenth "plumbed the innermost depths of the human soul."[26] Unfortunately, in this century, music, and the arts in general, have "quite deliberately entered a strange, disturbed and rather feeble stage of experimentation, in which theoretical notions take precedence over the desire for progress along established lines."[27] It seemed to Heisenberg that art has stripped away a presumed "straitjacket," with the attendant consequences.

Of course, Heisenberg would never give up music for lost. It is amusing to compare this reconstruction of his youthful views on this 'feeble' stage of art, made before his own involvement with the perplexing quantum world and the often

confused theories that preceded the Copenhagen Interpretation, with those that came with the wisdom of hindsight: "[this stage of art] probably corresponds to that confused preliminary phase which also had to be undergone in science."[28] At the time, however, it appeared that music rejected all its fruitful ties to the past, whereas science seemed firmly anchored in them: here was a "pursuit of clear objectives along fixed paths."[29] Yet, that this quest of clear objectives along well-travelled paths had automatically thrown up challenges to the whole philosophical basis of science, the conception of space and time, and that of causality, leaving physicists on "terra incognita", was an exciting notion for Heisenberg, who confesses that he is highly tempted to play some part in this pursuit. It was more than simply exciting: it seemed to him that these questions were of great importance, since they did not arise from the subjective ramblings of the physicists: "one may say that a fruitful period is characterized by the fact that the problems are given, that we need not invent them."[30] Here was the opportunity of clarity, to provide the world with a deeper understanding of its order; Heisenberg held the conviction, along with Plato and many other great thinkers and scientists, that recognition of order and harmony in the study of nature must say something about that central order (little yet did the young man realize how considerably our study of nature was a study of ourselves and our relation to the One, as well). Of

course, he knew that art and music must say something about it as well, but "I firmly believe that in atomic physics we are on the track of far more important relations, far more important structures, than in music. But I freely admit that 150 years ago things were the other way around."[31]

By no means is this elevation of science over art an elevation of objective knowledge over subjective. Rather, he is only saying that art has lost its strength as an avenue to the absolute by exploding the guiding principles that empower it: "only when the hankering after the absolute is subordinated to appropriate forms - in science to logical thought; in music to the rules of harmony and counterpoint - only then, only under this extreme constraint, can it reveal its full power."[32] When so guided, it may happen that the soul catches a glimpse of the absolute, at which "the soul is awe-stricken and shudders at the sight of the Beautiful."[33] Heisenberg himself speaks of his own experience of 'shuddering' before the Beautiful, that which gave him a life-long certainty concerning the central order, and a deep understanding of his relationship to it.

It happened when he was still a youth, a youth recently introduced to the concept of order through a reading of Plato, specifically the Timaeus. His interest centred in Plato's conception of the smallest units of matter, which Plato had reduced to mathematical forms (the five perfect geometrical solids). Yet, it was not so much the details of Plato's

physics that caught young Heisenberg's attention, but that Plato thought he could recognize order in natural phenomena at all. At the time, the whole question of order, not just that confined to the physical world, was an important one to Heisenberg, who had just seen the old European order crumble before his very eyes in the first World War. He suspected (doubtless in the tradition of the true German) that there was an order, a central order, but certainly could find no evidence of it: Although many new orders were being propounded at that point, he felt sure that the different orders were in danger of clashing, and concluded that this was because they were only partial orders, fragments of the central order; there existed no unifying centre. This struck him particularly during an assembly at Prunn Castle, where he silently listened to a passionate debate among German youth concerning the new order:

> Its absence [a unifying centre] was brought home to me the longer I listened. I was suffering almost physically, but I was quite unable to discover a way to the centre through the thicket of conflicting opinions. Thus the hours ticked by, while more speeches were delivered and more disputes were born...The talk was still going on when, quite suddenly, a young violinist appeared high on a balcony above the courtyard. There was a hush, as high above us, he struck up the first great D minor chords of Bach's Chaconne. All at once, with utter certainty, I had found my link with the centre. The moonlit Altmühltal Valley below would have been reason enough for a romantic transfiguration; but that was not it. The clear phrases of the Chaconne touched me like a cool wind, breaking through the mist and revealing the towering structures beyond. There had always been a path to the central order in the language of music, in philosophy and in religion, today no less than in Plato's day and in Bach's. That I now knew from my own experience [emphasis added].[34]

It is this music, composed about 150 years before his time, that first allowed him to realize the bond with the absolute. Certainly, it is intriguing that he saw in a moment how the various paths - and he spent his life in showing that science was another such path - all lead to the same end; admittedly, though, this is possible through rational comparison, since Western roots have determined the direction of the various paths. However, it would appear that he realized something even more fascinating, at least to the present writer. The modern world, if it gives any validity at all to that which is not science, tends to think that philosophy, art, and science each begin their ascent from widely separated points and methods, and, at best, meet in some middle ground; it can almost be characterized as a meeting of facts and feelings. However, what Heisenberg seems to have realized in this profound moment was not only the absolute, though this is undeniably important, but significantly, our relation to it; that is, the opening of his "inner core" ("die Mitte bezeichnet bei einem Wesen"),[35] his soul, through the force of the Chaconne made infinitely clear to him the nature of the soul, and thus the method for absolute discovery, that shuddering of the soul before the Beautiful. It was this experience, coupled with his experience of science, which taught him that science was as powerful as art; further, it could almost be said that, for Heisenberg, science is art, and functions the same way as an avenue to

religious understanding, which, as has been pointed out, is not the same as an understanding of religion.

Further clarification of this last note is not superfluous. It is apparent that, for Heisenberg, there exists a qualitative difference between the definition of religion, and the meaning of religion: an understanding of religion as the human concern with his/her relation to the central order is not at all religious understanding, the discovery of that relation. He learned this from Bohr, who took some exception to Heisenberg's attempt at equating the epistemology of science and religion. That is, Heisenberg once tried to show that a scientific statement like 'there is infinity', where infinity exists as a necessary concept in modern mathematics, though it has no correlate, has a parallel in religious statements like 'there is a living God'; he wondered, then, "is it correct to look upon the religious 'there is' as just another, though different, attempt to reach ever higher levels of abstraction?"[36] Bohr replied, and this paper will demonstrate, that with respect to the epistemological side of the problem, the comparison is acceptable. Nonetheless,

> ...in other respects it is inadequate. In mathematics we can take our inner distance from the content of our statements. In the final analysis mathematics is a mental game that we can play or not play as we choose. Religion, on the other hand, deals with ourselves, with our life and death; its promises are meant to govern our actions and thus, at least indirectly, our very existence. We cannot just look at them impassively from the outside.[37]

Bohr continued that no matter what, the individual must speak of life, death, and his relation to those around him, and insisted that "epistemological sophistries cannot possibly help him to attain these ends."[38] Therefore, the critical understanding of the spiritual content of religion, and the acceptance of that content are related, but complementary, by which he means that though both are necessary to the full understanding of religion, they are mutually exclusive. Critical understanding cannot impart the understanding arrived at through conscious acceptance, which "fills the individual with strength of purpose, helps him to overcome doubts and, if he has to suffer, provides him with the kind of solace that only a sense of being sheltered under an all-embracing roof can grant."[39]

Heisenberg finds a particularly illuminating example of this distinction in much of modern science, where a critical understanding of nature exists, i.e., mathematically ordered and beautiful (modern science, believes Heisenberg, could not exist without this understanding), but conscious acceptance of this beauty, an effort to experience it, often has no place there. It is in fact Heisenberg's conscious acceptance of the beauty of nature that made mathematical science for him a matter of the utmost human importance, that is, religious in nature, although only in connection with other modes of religious understandings; this is where he might differ from Bohr. These notions will be discussed in much more detail

below. Essentially, though, he is in agreement with his teacher, and makes that distinction between an understanding of religion and religious understanding. Thus, he echoes Bohr's conviction that the discovery and acceptance of the latter understanding establishes two crucial foundations. The first is that of ethics:

> Religion proper speaks not of norms...but of guiding ideals, by which we should govern our conduct and which we can at best only approximate. These ideals do not spring from inspection of the immediately visible world but from the region of the structures lying behind it, which Plato spoke of as the world of Ideas, and concerning which we are told in the Bible, 'God is Spirit.'[40]

Secondly, religious understanding is "above all" the foundation of trust, "in the world, in the meaning of existence."[41] Thus, Heisenberg trusts that the central order will "win out", that spring will follow winter, that war-torn Germany will be rebuilt, both physically and spiritually: "time and again destruction is transformed into order."[42] It is through this religious understanding that one gains confidence in the ideals upon which one bases one's conduct, so that whatever the consequences of an action, be they unpleasant and cause suffering personally or to others, one may rest assured that in the broad scheme of things, that action has meaning, that it is a vital part of the central order; what Heisenberg suggests here is trust in "a kind of superstructure that lends meaning to the individual events,"[43] a trust that one's decisions conform to the

perhaps unfathomable plans of the central order. In more traditional language, the final understanding is the elimination of one's own will, that one may be filled with God's.[44]

The above requires a good deal more explanation and support, which will be given at the relevant time. This is not the time, since it is the final understanding, which Heisenberg believes is achieved only after one has worked through the appropriate avenues of religious discovery, of which science is most definitely one. As we emphasized above, religious understanding is realized not in isolation from the world, but through the world, and there, through the appropriate forms. Thus, in all honesty to Heisenberg, even at the expense of consistency and organization here, a discussion of that deepest meaning of religion must wait until the avenues to this final understanding are worked through. Now, for our purposes, it would be impossible to ignore art and simply focus on science as an avenue to religious understanding. Were art to be neglected, it is believed that the focus on science might amount to a recital of dry details. Heisenberg in no way understands science as a tedious, analytic avenue (- "I really cannot see why so many of our compatriots should find the scientific approach dull and disappointing"[45]); science generates in him the same exhilaration as did art. There is, then, a desire here to illustrate and perhaps evoke this exhilaration, which most can

experience through art and few through science. More importantly, it is felt that an understanding of the way Heisenberg sees art functioning as an avenue to absolute discovery illuminates to a greater extent that same process of science. Finally, science can never exist as an avenue without the existence of art as such: without the structures unveiled by art, those structures of science have no meaning.

NOTES TO CHAPTER ONE

1.Heisenberg, Physics and Beyond, p. 214; Heisenberg, Der Teil und das Ganze, p.290: "Aber ich habe doch den Eindruck, daß es sich in allen Formulierungen um die Beziehungen der Menschen zur zentralen Ordnung der Welt handelt.

2.Heisenberg, The Physicist's Conception of Nature, trans. by Arnold J. Pomerans (London: Hutchinson, 1958), p. 52; Heisenberg, Das Naturbild der heutigen Physik (Hamburg: Rowohlt, 1955), p. 36: "...daß ja unser ganzes kulturelles Leben, unser Handeln, Denken und Fühlen in der geistigen Wesen, das in der Antike begonnen hat, an dessen Anfang griechische Kunst, griechische Dichtung und griechische Philosophie stehen..."

3.Heisenberg, The Physicist's Conception of Nature, p.67; Heisenberg, Das Naturbild der heutigen Physik, p. 46: "Wir wollen, daß unsere Jugend aller äußeren Wirrnis zum Trotz in der geistigen Luft des Abendlandes aufwächst, um an die Kraftquellen zu gelangen, von denen unser Erdteil durch über zwei Jahrtausende gelebt hat."

4.Heisenberg, Physics and Beyond, p. 186; Heisenberg, Der Teil und das Ganze, p. 254: "Vielleicht haben wir Deutschen sogar an dieser Stelle eine besondere Aufgabe, gerade weil das Absolute auf uns eine solch merkwürdige Faszination ausübt."

5.Ibid.; Heisenberg, Der Teil und das Ganze, p. 253: "Wir meinen, Freiheit gebe es nur dort, wo wir uns diesem Zwang entziehen können, also im Reich der Phantasie, im Traum, im Rausch der Hingabe an eine Utopie."

6.Ibid.; Heisenberg, Der Teil und das Ganze, p. 254: "...in der Wissenschaft und in der Kunst ist das prinzipielle Denken, so wie wir es in seiner großartigsten Form aus dem alten Griechenland kennen, doch noch erfolgreicher gewesen. Wenn in Deutschland wissenschaftliche oder künstlerische Leistungen entstanden sind, die die Welt verändert haben - man kann ja an Hegel und Marx, an Planck und Einstein, oder in der Musik an Beethoven und Schubert denken -, so ist das nur durch diese Beziehung zum Absoluten, durch das prinzipielle Denken bis zur letzen Konsequenz möglich gewesen."

7.Heisenberg, Across the Frontiers, trans. by Peter Heath (New York: Harper and Row, 1974), p. 117; Heisenberg, Schritte über Grenzen (München: Piper, 1971) p. 201: "Platos Symmetrien waren noch nicht die richtigen..."

8.Heisenberg, Physics and Beyond (revised translation), p. 246; Heisenberg, Der Teil und das Ganze, p. 333: "Nur die Fülle führt zur Klarheit."

9.C.F. von Weizsäcker, "Platonic Natural Science in the Course of History," trans. by Renee Weber, Main Currents, vol. 29, S-O, 1972.

10.Heisenberg, Physics and Beyond, p. xviii; Heisenberg, Der Teil und das Ganze, p. 10: "Vielleicht kann das vorliegende Buch auch dazu beitragen, die Grundlage dafür zu schaffen."

11.Across the Frontiers, p. 218; Heisenberg, Schritte über Grenzen, p. 304: "Da ist zunächst die Tatasche, daß der Mensch seine geistigen Kräfte nur in Relation zu einer menschlichen Gesellschaft entwickeln kann."

12.Heisenberg, Physics and Beyond, p. xvii; Heisenberg, Der Teil und das Ganze, p. 9: "Wissenschaft wird von Menschen gemacht. Dieser an sich selbstverständliche Sachverhalt gerät leicht in Vergessenheit..."

13.Ibid.; Heisenberg, Der Teil und das Ganze, p. 9: "Naturwissenschaft beruht auf Experimenten, sie gelangt zu ihren Ergebnissen durch die Gespräche der in ihr Tätigen, die miteinander über die Deutung der Experimente beraten. Solche Gespräche bilden den Hauptinhalt des Buches. An ihnen soll deutlich gemacht werden, daß Wissenschaft im Gespräch entsteht."

14.Heisenberg, "Scientific Truth and Religious Truth," trans. not acknowledged, Universitas, vol. 16, no. 1, 1974, p. 5; Heisenberg, Schritte über Grenzen, p. 304: "Gerade die Fähigkeiten, die ihn vor allen anderen Lebewesen auszeichnen, das Übergreifen über das unmittelbar sinnlich Gegebene hinaus, das Erkennen weiter Zusammenhänge, sie beruhen darauf, daß er in eine Gemeinschaft von sprechenden und denkenden Wesen eingebettet ist."

15.Heisenberg, "Tradition in Science," Dialogue, vol. 7, no. 1, 1974, p. 54.

16.Heisenberg, Across the Frontiers, p. 59; Heisenberg, Schritte über Grenzen, p. 140: "Sicher ist die Grundlage dieses sehr vielschichtigen Wesens immer noch der konservative katholische Geist der einheimischen Bevölkerung."

17. Of course, in Munich's one-time existence as a headquarters of "the Movement", Heisenberg sees a great tragedy of human weakness: the adventurous spirit in politics overtook the wisdom that might have guided it. However, then and in the future, Heisenberg is sure that "there will be strong forces to preserve the good old ways wherever they can be preserved" (Across the Frontiers, p. 60), a contention that will become better understood further below.

18.Ibid., p. 61; Heisenberg, Schritte über Grenzen, p. 142: "Es kommt eben sehr viel Gutes heraus, wenn man versucht, trotz der anfänglich so unüberwindlich scheinenden Verschiedenheiten irgendwie mit gutem Willem zusammenzuleben und vielleicht gerade

durch das Zusammenwirken recht verschiedenartiger Kräfte etwas Neues zustande zu bringen."

19.Heisenberg, Physics and Beyond, p. 23; Heisenberg, Der Teil und das Ganze, p. 40: "Vielleicht erscheinen uns Gestalten wie Bach oder Mozart nur deshalb als Könige der Musik, weil sie für zwei Jahrhunderte so vielen kleineren Musikern die Möglichkeit gegeben haben, in größter Sorgfalt und Gewissenhaftigkeit ihre Gedanken nachzuvollziehen, neu zu interpretieren und damit den Zuhörern verständlich zu machen."

20.Ibid.; Heisenberg, Der Teil und das Ganze, p. 40: "Auch in diesen Zeiten kommt es auf die gewissenhafte, bis in alle Einzelheiten genaue Arbeit an. Alles, was nicht mit vollem Einsatz gemacht ist, wird sowieso vergessen und verdient nicht, auch nur erwahnt zu werden."

21.Ibid.; Heisenberg, Der Teil und das Ganze, p. 40: "Aber dann bringt dieser langsame Prozeß, in dem sich mit dem Wandel der Zeiten auch der Inhalt der betreffenden Disziplin verändert, plötzlich und manchmal ganz unerwartet neue Möglichkeiten, neue Inhalte hervor. Große Begabungen werden von diesem Vorgang, von den Wachstumskräften, die hier spürbar werden, gewissermaßen magisch angezogen, und so kommt es, daß innerhalb weniger Jahrzente auf einem engen Raum die bedeutendsten Kunstwerke geschaffen oder wissenschaftliche Entdekkungen größter Wichtigkeit gemacht werden."

22.Heisenberg, Across the Frontiers, p. 220; Heisenberg, Schritte über Ganze, p.307: "[Religion ist...] von entscheidender Bedeutung für die Kunst."

23.Heisenberg, Physics and Beyond, p. 247; Heisenberg, Der Teil und das Ganze, p. 334: "...die von Lebenskraft und Freude überquillt und in der sich das Vertrauen in die zentrale Ordnung überall gegen Kleinmut und Müdigkeit durchsetzt."

24.Heisenberg, Across the Frontiers, p. 220; Heisenberg, Schritte über Grenzen, p. 307: "Ein Blick in die Geschichte der verschiedensten Kulturkreise lehrt, daß man in der Tat die geistige Gestalt einer früheren Zeit am unmittelbarsten aus den noch erhaltenen Kunstwerken erschließen kann, selbst wenn man die religiöse Lehre, in der die geistige Gestalt formuliert worden ist, kaum mehr kennt."

25.Heisenberg, Physics and Beyond, p. 18; Heisenberg, Der Teil und das Ganze, p. 32: "In der Musik habe ich den Eindruck, daß die Kompositionen der letzten Jahre nicht mehr so überzeugend sind wie die der früheren Zeiten."

26.Ibid.; Heisenberg, Der Teil und das Ganze, p. 34: "...die romantische Musik des 19. Jahrhunderts ist bis in die innersten Tiefen der menschlichen Seele vorgedrungen."

27.Ibid., p. 19: Heisenberg, Der Teil und das Ganze, p. 34: "[Die Musik] scheint in ein merkwürdig unruhiges und vielleicht schwächliches Experimentierstadium zu geraten, in dem theoretische Überlegungen eine größere Rolle spielen als das sichere Bewußtsein eines Fortschritts auf vorbestimmter Bahn."

28.Heisenberg, Across the Frontiers, p. 152; Heisenberg, Schritte über Grenzen, p. 238: "...es entspricht warscheinlich eher jenem verworrenen Vorstadium, das auch in der Wissenschaft durchschritten werden mußte..."

29.Heisenberg, Physics and Beyond, p. 19; Heisenberg, Der Teil und das Ganze, p. 34: "Dort hat die Verfolgung des vorgezeichneten Weges...von selbst zu Problemen gefürt..."

30.Heisenberg, Encounters with Einstein: And Other Essays on People, Places, and Particles (Princeton: Princeton University Press, 1989) p. 3; originally published by the Seabury Press in 1983 as Tradition in Science.

31.Heisenberg, Physics and Beyond, p. 22; Heisenberg, Der Teil und das Ganze, p. 38: "Ich glaube also, daß man heute in der Atomphysik wichtigeren Zusammenhängen, wichtigeren Strukturen auf die Spur kommen kann als in der Musik. Aber ich gebe gern zu, daß vor 150 Jahren gerade umgekehrt gewesen ist."

32. Ibid., pp. 253-254; Heisenberg, Der Teil und das Ganze, p. 187: "Also nur dort, wo sich das Streben nach dem Absoluten dem Zwang der Form unterordnet, in der Wissenschaft dem nüchternen logischen Denken und in der Musik den Regeln der Harmonielehre und der Kontrapunktik, nur dort, nur in dieser äußersten Spannung kann es seine wirkliche Kraft entfalten."

33.Heisenberg, Across the Frontiers, p. 187; Heisenberg, Schritte über Grenzen, p. 257: "Die Seele erschrickt, sie erschaudert beim Anblick des Schönen..."

34.Heisenberg, Physics and Beyond, p. 11; Heisenberg, Der Teil und das Ganze, p. 24: "Das Fehlen dieser wirksamen Mitte wurde mir immer quälender bewußt, je länger ich zuhörte: ich litt fast physisch darunter, aber ich wäre selbst nicht imstande gewesen, aus dem Dickicht der widerstreitenden Meinungen einen Weg in den zentralen Bereich zurückzufinden. So vergingen Stunden, und es wurden Reden gehalten und Streitgespräche geführt. Die Schatten auf dem Burghof wurden länger, und schließlich folgte dem heißen Tag eine graublaue Dämmerung und eine mondhelle Nacht. Immer noch wurde gesprochen, aber dann erschien oben auf dem Balkon über dem Schloßhof ein junger Mensch mit einer Geige, und als es still geworden war, erklangen die ersten großen d-moll-Akkorde der Chaconne von Bach über uns. Da war die Verbindung zur Mitte auf einmal

unbezweifelbar hergestellt. Das vom Mondlicht übergossene Altmühltal unter uns wäre Grund genug für eine romantische Verzauberung gewesen; aber das war es nicht. Die klaren Figuren der Chaconne waren wie ein kühler Wind, der den Nebel zerriß und die scharfen Strukturen dahinter sichtbar werden ließ. Man konnte also vom zentralen Bereich sprechen, das war zu allen Zeiten möglich gewesen, bei Plato und bei Bach, in der Sprace der Musik oder der Philosophie oder der Religion, also mußte es auch jetzt und in Zukunft möglich sein. Das war das Erlebnis."

35.Ibid., p. 216; Heisenberg, Der Teil und das Ganze, p. 293.

36.Ibid., p. 90; Heisenberg, Der Teil und das Ganze, p. 126: "Könnte man...das Wort 'es gibt' in der Religion auch als ein Aufsteigen zu einer höheren Abstraktionsstufe auffassen?"

37.Ibid; Heisenberg, Der Teil und das Ganze, p.126: "Sofern es sich um die erkenntnistheoretische Seite des Problems handelt, mag dieser Vergleich wohl hingehen...Aber in anderer Hinsicht ist er doch ungenügend. In der Mathematik können wir uns vom Inhalt der Behauptungen innerlich distanzieren. Letzten Endes bleibt es da bei einem Spiel der Gedanken, an dem wir teilnehmen oder von dem wir uns ausschließen können. In der Religion aber handelt es sich um uns selbst, um unser Leben und unseren Tod, da gehören die Glaubenssätze zu den Grundlagen unseres Handelns und so zumindest indirekt zu den Grundlagen unserer Existenz. Wir können also nicht unbeteiligt von außen zusehen."

38.Ibid; Heisenberg, Der Teil und das Ganze, p. 127: "Daher helfen hier erkenntistheoretische Spitzfindigkeiten nichts."

39.Ibid., p. 91; Heisenberg, Der Teil und das Ganze, p. 127: "Von der bewußt vollzogenen Entscheidung geht für den Einzelnen eine Kraft aus, die ihn in seinem Handeln leitet, ihm über Unsicherheiten hinweghilft und ihm, wenn er leiden muß, den Trost spendet, den das Geborgensein in dem großen Zusammenhang gewähren kann."

40.Heisenberg, Across the Frontiers (revised translation), pp. 219-220; Heisenberg, Schritte über Grenzen, p. 306: "Die eigentliche Religion...spricht nicht von Normen, sondern von Leitbildern, nach denen wir unser Tun richten sollen und denen wir bestenfalls nahekommen können. Und diese Leitbilder entstammen nicht dem Anschauen der unmittelbar sichtbaren Welt, sondern dem Bereich der dahinter liegenden Strukturen, von dem Plato als dem Reich der Ideen gesprochen hat und über den in der Bibel der Satz steht: Gott ist Geist."

41.Ibid.; Heisenberg, Schritte über Grenzen, p. 306: "Die Religion ist...vor allem die Grundlage des Vertrauens."

42.Heisenberg, Physics and Beyond (revised translation), p. 215; Heisenberg, Der Teil und das Ganze, p. 292: "...Chaotisches sich immer wieder in Geordnetes verwandelt."

43.Ibid., p. 241; Heisenberg, Der Teil und das Ganze, p. 326: "[...es gibt] dem Einzelereignis einen Sinn."

44.Actually, Heisenberg does not use much traditional language; as he says, "I often have great difficulty in grasping what these ideas are meant to convey, but when that happens, I always try to translate them into modern terminology and to discover whether they throw up fresh answers" (Physics and Beyond, p. 211; Der Teil und das Ganze, p. 287: "Ich habe zwar manchmal Schwierigkeiten zu verstehen, was mit diesen Gedankengängen gemeint ist, und ich versuche dann, sie in eine moderne Terminologie zu übersetzen und nachzusehen, ob wir jetzt neue Antworten geben können"). Doubtless this reflects his conviction that religious understanding only comes through a real interplay between the world and ourselves, an interplay requiring the appropriate language.

45.Ibid., p. 186; Heisenberg, Der Teil und das Ganze, p. 254: "[ich kann] eigentlich nicht einsehen, warum viele unserer Landsleute das nur scheinbar nüchterne, wissenschaftliche Denken so enttäuschend finden."

CHAPTER TWO: ART

> ...The clear phrases of the Chaconne touched me like a cool wind, breaking through the mist and revealing the towering structures beyond.[1]

Clearly, Heisenberg sees art as a religious enterprise in that it leads to a discovery of our relatedness to the central order. Concerning method, the important passage quoted at length above appears to express Heisenberg's understanding of the Chaconne as not so much effecting a transformation in him, but more uncovering something that was already there; that is, the music unveiled his soul, "revealing the towering structures beyond." It is in these towering structures that Heisenberg appears to see his link with the unifying centre. Of course, this statement necessitates both an investigation into these structures, and the manner in which art unveils them. It is interesting to note that in this connection some of his clarification came from his scientific work; however, there will be no explicit focus on these clarifying influences, since we only want to demonstrate that art (however Heisenberg came to his understanding of it) acts almost as an archetypical pattern of understanding, as seen later in the exploration of science and action. A discussion of art's ability to reach levels far beyond those touched by science is essential, for it establishes the spiritual primacy of art over science, although that primacy is not an arbitrary ruling by Heisenberg: rather, as he explains, art has not limited itself in the way that science consciously has.

Finally, a focus must be made on the almost paradoxical importance of scientific thought for the serious reclamation of art, particularly by the western world, for although art may be more effective in the unveiling of the most significant structures in the soul, it is not able to act so in the modern worldview, which has lost sight of the central order.

Actually, anyone familiar with Platonic thought would immediately grasp the connection between the structures in the "inner core" and the "unifying centre" itself, between the soul and the One. It must first be established, though, that Heisenberg did indeed hold to Platonic thought, and this is easily done: he frequently introduces it into his writings, particularly when discussing the Platonic implications of quantum mechanics. Of course, he often turns to the world of Greek antiquity, without confining himself to only certain philosophers. His familiarity with the ancients, even those who do not concur with Platonic thinking, is quite clear; and his esteem for each stems from the genuine concern shown for a resolution to the classical question of principle, that is, the problem of the "one" and the "many". As discussed above, this problem is intimately related to questions of action, which will be dealt with in detail presently; for the moment, the issue of principle is our interest.

This problem, of course, concerns the reality of the ever-changing variety of phenomena appearing to our senses, and the belief that it should be possible to trace them back

to one principle; Heisenberg asserts, "in order to understand [the infinite variety of things] we have to introduce some kind of order, and order means to recognize what is equal, it means some kind of unity. From this springs one fundamental principle, and at the same time the difficulty to derive from it the infinite variety of things."[2] Thus the question was also intimately connected to the problem of "Being" and "Becoming", in that the primary substance or principle, the One or undifferentiated Being - "as that which is eternal, uniform, and unlimited in space and time"[3] appears antithetical to the world of transience, variety and change, or Becoming. The concern at present is with the tracing back to the one fundamental principle. Here, though Heisenberg takes quite seriously and brings into the contemporary dialogue the answers given by other early philosophers, particularly those of the "materialists", as will be seen in the section dealing specifically with science, he is very much influenced by the understanding of those in the Platonic tradition, again, where "understanding," to begin with, is that "reduction of a colorful variety of phenomena to a general and simple principle."[4]

By assuming the possibility of this reduction of the "many" to the "one", there necessarily exists the assumption that the many are somehow related. For example, the ancient atomists concluded that all things were made up of tiny, indivisible particles of matter, and this was the relation.

Yet, any attempt at understanding must begin at a "many" that somehow exist as a whole, that is, that there exists order in the many, and an ordering principle that can be understood. This lack of ordering principle seems to Heisenberg the downfall of the theories of ancient atomists, who could not explain why the atoms move the way they do. For other philosophers, particularly Pythagoras and Plato, order was of the utmost concern; order was beauty. In line with the classical tradition, Heisenberg defines one level of beauty thus: "the proper conformity of the parts to one another and to the whole."[5] To illustrate this, consider the wide variety of sounds. In sound, of course, there is a great difference between "music", a word etymologically connected to the heavenly muses, and "noise", anciently associated with nausea: the first denotes sounds in harmony, in consonance, and the latter with those in discordance. Understanding sound as music is, to Heisenberg, nothing more than recognizing unitary features in the multiplicity: "we perceive that the individual parts fit together, that as parts they do indeed belong to the whole, and that without any reflection we feel the completeness and simplicity of this...system to be beautiful."[6]

Although humans have always been able to distinguish the two, music and noise, Heisenberg is fascinated by the deeper understanding engendered by the Pythagoreans, who went beyond perhaps a vague understanding of beauty in music, to an

electrifyingly clear one. Pythagoras himself is said to have discovered that vibrating strings, under equal tension, and whose lengths are in simple numerical ratio, will sound together in harmony. Thus the individual notes are the parts, the whole is the harmonious sound: the parts properly conform to each other and the whole. Underlying the whole is the unifying principle of the mathematical relation. The recognition is no longer in the realm of the intuitive, but has a real mathematical basis. In the Greek tradition of the time, this understanding was radically new. A mathematical relation assembles various independent parts into a whole, and so produced beauty. That mathematical relation, "the simple principle of limiting measure,"[7] was the key to order and harmony of the sounds, not the sounds themselves. Pythagoras extended his conception of mathematical harmony to the whole of Nature, calling the universe a "cosmos", which means beauty as well as order; the Pythagoreans concluded that the reality of things lay not in unordered matter, the world of Becoming, but in "the opposite limiting principle of form and measure, proportion and number;"[8] the forms are not imaginary nor unreal, but, eternal, unchanging, they are the truly real. They are responsible for the harmony, the "fitting", of the universe, and therefore its beauty, in the definition we have been using.

Clearly, then, Heisenberg does not consider beauty an accident, nor an illusion; recall his first definition: "the

proper conformity of the parts to one another and to the whole." Music is not a haphazard collection of sounds, but is whole and beautiful through simple mathematical relations: there exists there a unitary principle of form. The order that is beauty is intelligible order - we see and understand it. In fact, we could not recognize beauty if it were not intelligible, and the Pythagoreans established for Heisenberg this close connection between the intelligible and the beautiful: "For if the beautiful is conceived as a conformity of the parts to one another and the whole, and if, on the other hand, all understanding is first made possible by means of this formal connection, the experience of the beautiful becomes virtually identical with the experience of connections either understood or at least guessed at."[9] Thus, the experience of the beautiful is more than just the experience of the aesthetically pleasing; to know something as beautiful is to understand it; to understand it is to recognize a principle of order. For the physicist, re-cognition, "knowing again" ("erkennen"), is a crucial aspect of understanding, since he holds in Platonic fashion the principle of reminiscence. He often turns to Plato for authority.

There is little doubt that Pythagoras' understanding of the mathematical limiting principles aided Plato in both a clarification of the Socratic aspiration to an absolute ideal of human perfection, and its expansion into the whole of Nature; of course, we are now discussing his theory of Ideas.

Rather than attributing reality to the diverse phenomena, Plato gives it to the ideal shapes, the ordering principles which have wrought them: the material shapes are imperfect copies, shadow images, of the ideal shapes in reality. Thus, Plato distinguishes between a corporeal being accessible to our senses (a triangle), which will have accidental qualities (certain size, certain length, equilateral, isosceles, etc.), and a purely ideal being (The Triangle), apprehensible not through the senses, but only though acts of mind. Thus, to know a triangle by our senses is not to know it, since it is merely a shadow image of the real Triangle. We must grasp its idea, which we possess in ourselves, because we too are reproductions of the ideal beings: "As their name already indicates, the apprehension of Ideas by the human mind is more an artistic intuiting, a half-conscious imitation, than a knowledge conveyed by the understanding. It is a reminiscence of forms that were already implanted in this soul before its existence on earth."[10]

The one insight, that the forms are implanted, Heisenberg rightly sees as stretching throughout Western Christian history. One need only recall Augustine's Christianization of it,[11] or Eckhart's "divine spark." He also notes that the assumption of humanity's creation in God's spiritual image is the basis for modern science. For those early modern scientists, "Physics is reflection on the divine ideas of Creation."[12] As a scientist, then, he is particularly

inspired by Kepler's understanding of the innate archetypes, as Kepler calls them:

> But how have [the archetypes] come to be within? To this I answer that all pure Ideas or archetypal patterns of harmony, such as we were speaking of, are inherently present in those who are capable of apprehending them. But they are not first received into the mind by a conceptual process, being the product, rather, of a sort of instinctual intuition of pure quantity, and are innate in these individuals, just as the number of petals in a plant, say, is innate in its form principle, or the number of seed chambers is innate in the apple.[13]

Heisenberg actually prefers the term "structure" ("Struktur") over Idea, "since the word 'Idea' has acquired a rather too subjective taint."[14] He too is convinced that these structures, as the foundation for all existence, are of course "the essential reality." The physicist is further convinced, in line with the Platonic/Christian tradition, that these structures exist innately within us: "Of course", he states,

> we all know that our own reality depends on the structure of our consciousness; we can objectify no more than a small part of our world. But even when we try to probe into the subjective realm, we cannot ignore the central order or look upon the forms peopling this realm as mere phantoms or accidents.[15]

He is saying here that if we turn inward, we cannot ignore the base of our humanity, the soul, where the eternal, unchanging structures have been impressed: "the word 'soul' refers to the central order, to the inner core of a being whose outer manifestations may be highly diverse and pass our understanding."[16] Thus it is possible to reach both the soul of another individual, because there one recognizes the

structures of one's own soul, and the ultimate central order, because it is the model structure of our own central order. Recall that, for Heisenberg, the Chaconne cleared the mists from his soul, and the towering structures there shone through: "At that moment...when the true Ideas rise up, there occurs in the soul of him an altogether indescribable process of the highest intensity. It is the amazed awe that Plato speaks of in the Phaedrus, with which the soul remembers, as it were, something it had unconsciously possessed all along."[17] Here, then, do we grasp Heisenberg's understanding of the link between the towering structures of the soul and the central order.

Although this recognition of the central order is the highest (and perhaps rarest) of understanding, the question now concerns the arrival at this immediate recognition. For Plato, of course, the central order cannot be approached instantly by the mind, which, after escaping from the cave, must accustom itself to looking at first shadows, next images in water, and then things in the sunlight, before looking at the sun, or the Good, itself. These things, Ideas, in the upper world are real, though only given Being by the highest Good, which, like the sun, "provides not only the power of being seen for things seen, but...also their generation and growth and nurture."[18] Finally, once one has become used to those things in the sunlight, one's attention will be drawn to the sun itself, or to the Central idea, "that of the Beautiful

and the Good, in which the divine becomes visible and at sight of which the wings of the soul begin to grow."[19] Clearly, for Plato, the mind must begin recognition at a lower level, at the structures generated and illuminated by the central order, and work upwards to the highest itself.

Heisenberg agrees that the ascent begins at a lesser level; the initial recognition must be of the lower structures, the shadows outside, the things in the sunlight. How, though, does one have it re-cognized? Obviously, something is recalled, that is, something must be "seen" that has been "seen" before; it is, in fact, the second "seeing" that makes one aware that one has "seen" it before. Thus, to recognize the structures without, is to have them shine anew within; one begins to wake up to the contents of the soul, as Heisenberg did through Bach's music. These inner structures, however, lie deep in the soul, far from the rational concepts of consciousness; they are, in Heisenberg's words, our "inner core". Therefore, our memory of the structures must issue from the depth of our being if we are to understand the phenomena without, not an uncomplicated procedure: "as [Wolfgang] Pauli told us, all understanding is a protracted affair, inaugurated by processes in the unconsciousness long before the content of consciousness can be rationally formulated."[20] Concerning this matter, Heisenberg quotes Kepler (from Harmony of the World) at length:

> That faculty which perceives and recognizes the noble proportions in what is given to the senses, and in other

> things situated outside itself, must be ascribed to the lower regions of the soul. It lies very close to the faculty which supplies formal schemata to the senses, or deeper still, and thus adjacent to the purely vital power of the soul, which does not think discursively, i.e. in conclusions, as the philosophers do, and employs no considered method, and is thus not peculiar only to man, but also dwells in wild animals and the dear beasts of the field....Now, it might be asked how this faculty of the soul, which does not engage in conceptual thinking, and therefore have no proper knowledge of the harmonic relations, should be capable of recognizing what is given in the outside world. For to recognize is to compare the sense perception outside with the original pictures inside, and to judge that it conforms to them. Proclus has expressed the matter very finely with his simile of awakening, as from a dream. For just as the sensorily presented things in the outer world recall to us those which we formerly perceived in the dream, so also the mathematical relations given in sensibility call forth those intelligible archetypes, so that they now shine forth truly and vividly in the soul, where before they were only obscurely present there [emphasis added]...[21]

Naturally, for Kepler, the archetypes - the Ideas - are innate in the soul.

Heisenberg appears drawn to Pauli's perception of understanding, where the above "faculty" adjacent to the vital powers of the soul, is re-animated in the Jungian conception of archetypes, which function as instinctive patterns of ideation: "at this stage, the place of clear concepts is taken by images of a strongly emotional character, which are not thought but are seen pictorially, as it were, before the mind's eye. Insofar as these images are the expression of a suspected but still unknown state of affairs, they can also be called symbolic..."[22] This appears merely a restatement of Plato's other insight, that recognition of the Ideas is more an artistic intuiting, a half-conscious imitation.

Interestingly, Heisenberg notes that Kepler derived his conviction of the correctness of the Copernican system more from an archetype than from any particular data of astronomical data, an archetype he also used as a symbol for the Trinity: God is seen as in the centre of a sphere, the Son (working in the world) the sphere's surface, and the Holy Spirit corresponds to the beams that radiate from centre to the surface of the sphere. Heisenberg reiterates that "it is naturally characteristic of these primal images that they cannot be rationally or even intuitively described."[23] Nonetheless, their existence is of ultimate necessity, since the "archetypes function as the desired bridge between the sense perceptions and the Ideas."[24]

Notice the richness of Kepler's archetype: therein he recognized the correspondence of both the structure of the solar system and the mode of the Trinity with the Ideas innate in his soul, although in almost an indeterminate manner. Recall though that recognition only arises through presentation of content without: the archetypes express the pure Ideas of the mind, but they themselves must be expressed in a more formal way, that the mind be able to understand the particular content. That is, the realization of the archetypes is a response to particular situations or contents, "the interplay between the world and ourselves."[25] This is an important point for Heisenberg, who believes of realization of the absolute that "its very basis is reality; it can only be

attained through the combination of facts or thoughts in accordance with the laws of nature;"[26] walking through bombed-out Berlin, he makes the comment that "even this debris all around us is nothing but natural fact."[27] Thus, it is actual, factual content that recalls the representative archetypes, which then are translated into rational forms by, as Kepler would say, the faculty which supplies formal schemata to the senses. Heisenberg speaks of this translation, actually an "abstraction" ("Abstraktion") therefrom, the essence of which "consists in singling out one feature, which, in contrast to all other properties, is considered to be particularly important in this connection."[28] In connection with Kepler's questions concerning the structure of the solar system and the universe, the abstracted concept was that of harmonious geometry.

The same situation exists in art, which has a slightly different task than science: that is, to make understandable, to depict "the spirit, the basis or vital feeling, of the epoch in question."[29] That spirit is the content that determines the abstraction of concepts from the symbolic archetype: "The spirit of a time is probably a fact as objective as any fact in natural science, and this spirit brings out certain features of the world which are even independent of time, are in this sense eternal."[30] That is, certain basic structures of our existence become visible, become recognized, and are then illuminated. For example,

Heisenberg mentions the spirit of religious security that characterized the late Middle Ages, and thus its art; in the late eighteenth century, the world of feeling is depicted by Rousseau and Goethe's Werther.[31] Yet, even though it would appear that the richness of the archetype has been reduced by this abstraction (i.e., only religious security, only the world of feeling), the concepts initially formed "prove to be far more abundant and fruitful than we can initially perceive them to be. In later developments they display an independent ordering power - in promoting the creation of new forms and concepts, in providing insight into their connection and also in somehow demonstrating their own value...."[32]

The creation of forms is a crucial notion for Heisenberg: "the absence of specific forms can never, I think, truly characterize either an art or a science; for it is surely in the nature of such endeavors of the mind that they give shape to a content, and therefore create forms."[33] Not only does a dearth of forms not characterize an art or science, recall that for the physicist, "the moment we try to explode these forms, we produce the kind of chaos we can see all around us,"[34] the chaos resembling war-torn Berlin; the absence of forms is not only unproductive, it is thoroughly dangerous. Clearly, for the physicist, our endeavors must be constrained by the appropriate forms because they are the unifying ordering principles.

> This interplay, or struggle, if you will, between the content to be expressed and the restricted means for

> expressing it seems to me to be - much as it is in science -the unavoidable precondition for the emergence of genuine art. If no content presses for expression, the soil on which art may grow is lacking; if there are no limitations on the means of expression - if in music, for example, any desired sound can be produced - this struggle no longer exists, and the artist's effort is to some extent a beating of the air.[35]

Heisenberg, as mentioned, is dissatisfied with the state of modern art, large parts of which strike him as this chaotic 'beating of the air'. He attributes this to that explosion of forms he finds so dangerous: "It is well-known that particular trends in modern art are defined by the negation of determinate forms: there is talk of 'atonal' music or 'nonobjective' painting. Here there is no reference to content, and a reference to form only by way of negation."[36] As the physicist understands it, the problem is not merely an arbitrary decision on the part of the artistic community to experiment, to shake off the straitjacket of traditional forms. Rather, the artists seem to be experiencing a two-fold dilemma; they lack form because they lack content: "it often seems in modern art as if the very content that is to be presented is still contested or cannot be grasped."[37] Science, he notes, has no questions as to what requires explanation, but only how it is to be explained; in art, on the other hand, the question concerns <u>what</u> should be represented - "[and] there are too many rather than too few answers on how it should be done."[38]

Thus, this uncertainty of content results in the "unshaping" ("<u>Entstaltung</u>") of art; without content, concept

formation is impossible, as is the generation of forms. Of course, it was indicated earlier that Heisenberg sees a parallel in the unshaping of art and the unshaping of physics, that stage of confusion in science, whereby the old forms and concepts did not seem to fit any longer; the new content could not be forced into the old forms. So, the physicist speculates, it may be the case today that "the tendency to unshaping springs from a sense of life that not only seems to perceive the unreliability of all past forms but also descries behind the forms connections that later, perhaps may again be able to support life. This may be the most important content of modern art."[39] Of course, Heisenberg would never presume to dictate content; he simply wishes to remind that "although ultimately we are concerned with new shaping and the creation of new forms, these can only arise from new content; it can never be the other way around. To create new art, therefore, means I should suppose, to make new contents visible or audible, not merely to invent new forms."[40] The physicist cannot emphasize enough the necessity of genuinely new content for the creation of new forms. To exemplify, he calls to mind the new content forced upon science early this century, the results of numerous experiments on atoms. It was only this content that could ever have been the basis for the startling new concepts and forms of science. He says, "only when the novel is forced upon us by the problem itself, where it comes in a sense from outside and not from ourselves, does it later

have the power to transform."[41] Given that the concept, derived from the clear recognition of content, initiates the appropriate forms, the unifying ordering principles, it is not surprising that Heisenberg qualifies his use of the word 'creation' in relation to the forms; the various forms are initiated by the first formal concepts of the particular style of art,[42] not fabricated arbitrarily by the artist himself: "<u>one cannot invent such basic forms but only discover them. The basic forms possess a genuine objectivity</u> [emphasis added]."[43]

Once those basic structures within the concepts have been discovered, though perhaps 'revealed' is a more appropriate term here [literally, drawing back the veil], the possibilities for their elaboration are almost endless. For example, given the Idea of the Triangle, one may image it as an equilateral, an isosceles, a scalene, etc. Another example the physicist often uses is the development of Romanesque architecture through simple basic forms such as the semi-circle and rectangle, keeping in mind that they are not the true basic structures, but those as expressed through the language of geometry:

> From these basic forms there arise in the course of history new, more complicated and also altered forms, which yet can still in some way be regarded as variations on the same theme; and thus from the basic structures there emerges a new manner, a new style of building. We have the feeling, nonetheless, that the possibilities of development were already perceivable in these original forms, even at the outset; otherwise it would be scarcely comprehensible that many gifted artists should have so quickly resolved to pursue these new possibilities.[44]

It appears then, that a concept, although abstracted from a larger expression, is itself rich beyond our introductory awareness, and Heisenberg calls the process of discovery through the ground of this concept "the unfolding of abstract structures" ("Entfaltung abstrakter Strukturen"),[45] structures in which the Platonic Ideas manifest themselves.[46] For art is not creation, but revelation. It is not doing, but understanding.

Of course, it has been established that for Heisenberg, the recognition of the Ideas, though it begins at a lower level, is indeed one of re-cognition; the Ideas must exist without that we may recall the ones within. The universe is a 'cosmos'; we do not merely project our own thought patterns onto it. In like manner, then, the universe can be thought to be a revelation, more than a creation; as in art, so in nature there is an unfolding of abstract structures. Heisenberg notes Plato's contention that material things are the copies, the shadow images of the ideal shapes in reality, and moves onward: "moreover, as we should be tempted to continue today, these ideal shapes are actual [wirklich] because and insofar as they become 'act'-ive ['wirk'sam] in material events."[47] The matter is illustrated with Goethe's archetypal plant, "the primordial form, the basic structure, the shaping principle of plants,"[48] of which use as a key would make it possible to invent plants ad infinitum, as plants have been. The structures are more than static Ideas, a lifeless blueprint:

the basic structure is dynamic, a "form-giving force."[49] One recalls Plotinus, with whom Heisenberg was quite familiar, and his words that fire "sparkles and glows like an Idea."[50] Thus, Heisenberg observes that Goethe, in his discovery of the archetypal plant, qualified the nature of this Idea: "This ground phenomenon was not to be a fundamental principle, from which the various phenomena were to be deduced, but a basic appearance within which the manifold was to be discerned."[51] A return to Nature will be made in the next section. For the moment, we merely want to emphasize that in art, the discovery of the basic form in relation to a concept almost naturally unfolds into the richness characterizing its completion; one may say that the form, the basic structure, 'sparkles and glows' with that richness. Thus, one need not question the necessity of the unfolding, even though that objective, basic form is rich in itself, since it is in the nature of the form to unfold itself; it is actual because it is 'act-ual.'

In this connection, one wonders whether Heisenberg is thinking of Plotinus' definition of the essential nature of time as "generated according to the pattern of eternity, and as its moving image," where eternity can be spoken of "as a life which is here and now endless because it is total and expends nothing of itself, since it has no past and future;"[52] that is, eternity is an eternal present, and time as the moving image of that eternal present. For us, this appears to mean that the basic structure must unfold through

time, rather than remain fully accessible in itself. Heisenberg does in fact explicitly refer to a conception of eternity similar to that of that the ancient philosopher of time, quoting the Plotinus-influenced Augustine: "Only for us is time passing by; it is expected by us as future; it passes by us as the present moment and is remembered by us as past. But God is not in time; a thousand years are for Him as one day, and one day as a thousand years...For God the whole course of the universe is given at once."[53] As for time, there exist, for the physicist, various levels of applicability to the concept of time, again demonstrating the richness of any concept. For example, there is our 'common sense' conception of it. A different understanding is arrived at through general and special relativity. Yet, apart from these questions of time which can be asked, "and partly answered on an empirical basis,"[54] Heisenberg seems to see time on a completely different level, as a crucial aspect for the completeness of artistic discovery. He often notes that the complete unfolding of a basic structure occurs only through time: "the work of several generations is needed to develop that formal style which later is called the style of the art, from its simple beginning to the wealth of elaborate forms which characterize its completion."[55] It appears that this understanding of time, in connection with the unfolding of the basic forms, can be described as the moving image of eternity. Of course, Heisenberg never says this explicitly,

but his whole approach seems to suggest that this could very well be so.

Nonetheless, even if the above conclusion is considered simply too speculative, Heisenberg does give explicit reasons for the necessity of the unfolding: given the gifted artists in whom the forms are revealed, the unfolding of that ordering structure initiated by the concept is valuable in the development of new forms and concepts. Although our focus is primarily art, Heisenberg's example from early number theory is particularly helpful in this regard: The concept of number (i.e., instead of looking at cows and all their features in general, one abstracts from the cows an amount, e.g. not brown cows, nor big cows, but ten cows), initiates certain forms: counting and simple calculating operations. Number and that resultant theory of numerical relations, established the possibility of comparing lengths by measurement.

> From there it became possible to develop a scientific geometry, whose concepts already go beyond those of number theory. On attempting, in this fashion, to found geometry on number theory, the Pythagoreans had already run into difficulty over the relation of incommensurable lengths, and had thereby been driven to enlarge their stock of numbers; they were bound, in a sense, to invent the concept of an irrational number. Moving on from there, the Greeks arrived at the concept of the continuum and at the famous paradoxes later studied by the philosopher Zeno...we merely wish to point out the wealth of forms implicitly contained in the concept of number and capable of being extracted from it.[56]

Thus, the unfolding of forms is essential for further understanding: the forms that initiated the new concepts and its forms are integral to discovery of the new. In art, there

is a fundamental form, expressed through "equality and inequality, repetition and symmetry, certain group structures,"[57] with which it is impossible to dispense. It is the basis of all later art, even that art which is trying to portray something entirely different than that which introduced the basic form. There is an unfolding and elaboration, and from that elaboration more unfolding and elaboration; in many ways, the process can almost be likened to the weaving of a huge tapestry, at base of which is the elementary weaving action, which must be used at all times if the whole design or picture is to be revealed. Each concept is part of the picture, and although we use the basic weaving action, we are also weaving with various-colored and -textured threads that are determined by the part of the design on which we are working. Of course, this is simply a metaphor, and cannot be taken too far: for Heisenberg, the tapestry, that overarching superstructure, is not created by ourselves, but uncovered.

The fact that art is an ongoing process, that it can never rest at the unveiling of one basic structure, of one 'truth', is of decisive importance for the physicist, since understanding is also a constant process. Eckhart once said that if people were to live a thousand years or longer, they could still grow in love; in like manner, Heisenberg maintains that the human mind must never stop at one point, but must continue to grow in understanding:

> 'The full mind is alone the clear, and truth dwells in the deeps.' The full mind, in our case, is not only an abundance of experience but also an abundance of concepts by means of which we can speak about our problems and about phenomena in general.[58]

Thus, the difference between, say, Medieval art and Romantic art is not that one images truth more clearly than does the other. Rather, each illumines an aspect of truth which the other cannot: "The opposite of a correct statement is a false statement, but the opposite of a profound truth may well be another profound truth."[59] The full mind is the one which accepts the insights that each has to offer, thereby deepening its understanding of its relationship to the central order; that relationship is simply too rich to be contained in any one formulation - "Our quest for understanding is like a quest without a bottom."[60] The same understanding applies to the multiplicity of religions, and it is clear from the whole of his works that Heisenberg is in total agreement with the following words of Bohr:

> ...I can quite understand why we cannot speak about the content of religion in an objectifying language. The fact that different religions try to express this content in quite distinct spiritual forms is no real objection. Perhaps we ought to look upon these different forms as complementary descriptions which, though they exclude one another, are needed to convey the rich possibilities flowing from man's relationship with the central order.[61]

Hence, we do uncover that tapestry, piece by piece, although it is not a simple process: as it has been mentioned, the completion of that unfolding process takes a long period of time. That is, when the forms initiated by the concept are

spent, the concept can be considered fully revealed (at least as revealed as it possibly can be for us). Actually, this is probably going too far, for, as Heisenberg says,

> Any concepts or words which have been formed in the past through the interplay between the world and ourselves are not really sharply defined with respect to their meaning; that is to say, we do not know exactly how far they will help us in finding our way in the world. We often know that they can be applied to a wide range of inner and outer experience, but we practically never know precisely the limits of their applicability.[62]

There is a positive and negative aspect to this uncertainty regarding the limits of a concept: on the one hand, the uncertainty pushes one forward in the use of a concept, which, as we have discovered, can be very fruitful; one the other hand, there is a danger in continuing to press forward with a concept when its limits have already been reached. Yet, there seems an almost natural clue concerning the discovery of those limits in a particular connection; when the revelation is complete, there is no longer any compulsion, nor any interest, to continue a process already concluded:

> The interest of the artist is concentrated on this process of crystallization, where the material of the art takes, through his action, the various forms that are initiated by the first formal concepts of this style. After the completion the interest must fade again, because the word 'interest' means: to be with something, to take part in a process of life, but this process has then come to an end.[63]

Recall that the formation of a concept was in response to a particular concern; when that concern has been fully addressed, the concept has served its purpose in that regard - the content has been fully understood in that connection.

Attention will turn to the content inevitably brought out during the course of the previous development, and the concepts there initiated. Or, in less dry terms, a basic structure has been revealed, a truth realized, and in that bottomless quest for understanding, the pursuit of truth must continue.

Of course, there exists a qualification for that genuine artistic discovery: it can only occur through true dedication, through careful work and attention to detail; "Everything that is not done with utter devotion falls into oblivion and, in fact, does not deserve to be remembered."[64] That devotion, it appears, is very much tied to the "only possible compass by which mankind could be guided in seeking its course through the centuries" - the "one, the good, and the true."[65] Goethe, for example, in his pursuit of ultimate principles conceived that search to be one for the "God-given structures"[66] underlying the appearance; thus, the search is not one for mere rational understanding of content, but for the divine order perceivable in the content experienced, that which causes it to shine within. Heisenberg points out that, in a work such as "Bequest of the Ancient Persian Faith," it is no mere poetic metaphor for Goethe that the believer is moved by the sight of the sun rising over the mountains:

> God upon His throne then to proclaim,
> Him, the life-fount's mighty Lord, to name,
> Worthily to prize that glorious sight,
> And to wander on beneath His light.[67]

The God-given structures can be construed by more than the mere formal understanding; they may also, and should be, "immediately discerned, experienced and felt."[68] This is the moment, it would seem, that the structures are truly uncovered within. In one conversation, a young Heisenberg notes of Einstein's theory of relativity that "You might even say that I have grasped the theory with my brain, but not yet with my heart."[69] That is, understanding is more than just a knowledge of the formal connections and basic principles: understanding is something that one experiences deeply within one's self. Thus, one cannot approach the one, the good and the true by mere dianoia, the ability to analyze in detail, the result of logical deduction, as Heisenberg finds it defined by Plato.[70] Devotion is characterized by a profound desire to genuinely experience that reality "with the heart," and thus the pursuit of those structures, in which the Ideas are manifest, must be an exhaustive one. As Goethe states and Heisenberg appears to agree, "'Seeing, knowing, sensing, believing and whatever all the feelers may be called, whereby man gropes about in this universe, must then genuinely work together, if we wish to fulfil our important, though difficult, task.'"[71] Only when one can "see, feel, and sense" ("schauen, fühlen, ahnen") that ground structure or form has one attained higher knowledge.

At this point, it is important to our discussion to remember that although the basic structures, the Ideas, whose

discovery is generated by the concepts, are of high value, they are not quite the highest; as established earlier, they are only given Being by the highest Good, which is the fundamental principle of the many Ideas: the realm of seemingly separate values and realities coalesce into One. Again, the mind cannot approach that central order without accustoming itself to looking at things in the 'sunlight', before looking directly at the sun, or the One. Heisenberg sees that not only are the various concepts crucial for the illumination of the basic structures, those things in the sunlight, and for the discovery of more such 'real' objects, but agrees with Plato that they are also the ground structures for the further upward movement of the mind, to that moment of 'amazed awe' which Heisenberg experienced through the Chaconne. Here, Heisenberg calls into play that Platonic episteme, which is "precisely that immediate awareness at which one can halt and behind which there is no need to seek anything further."[72] Plotinus describes this upward ascent as almost a natural consequence of a mind aware of and grounded in those basic structures:

> It is there that one lets all study go; up to a point one has been led along and settled firmly in beauty and as far as this one thinks that in which one is, but is carried out of it by a surge of the wave of Intellect itself and lifted on high by a kind of swell and sees suddenly, not knowing how, but the vision fills his eyes with light and does not make him see something else by it, but the light itself is what he sees. For there is not in the Good something seen and its light, nor intellect and object of intellect, but a ray which generates these afterwards and lets them be beside it; but he himself is the ray which only generates Intellect

> and does extinguish itself in the generation, but it itself abides, and that Intellect comes to be because this Good exists. For if this was not of the kind it is, that would not have come into existence.[73]

It is not unwarranted to cite Plotinus' insights when Heisenberg himself does not often do so. It can be argued that in a crucial reference to the ancient philosopher by the physicist, all the above references become justified: in a discussion of the meaning of beauty, one definition of which has already been examined, he recalls Plotinus' higher definition of beauty, in which no more is heard of the parts - "Beauty is the translucence, through the material phenomena, of the eternal splendor of the one."[74] To experience art is to be swept upward, until one sees in that work of art the soul's link to the One itself, to see, feel, know and believe that this splendor <u>is</u>, and to see, feel, know and believe that, as Plotinus says, "we too have a share in eternity," in the divine splendor. Heisenberg simply cannot, and does not, recall the definition without a thorough understanding of its total implication; the descriptions of his own profound discovery of his link with the central order and his insights on diverse other matters prove that he is well aware of the depth of the tradition embodied and further unfolded by Plotinus. The truth that Heisenberg is seeking to understand is the same, and he seeks to understand it in the same way; thus, he repeats the Latin motto, "Pulchritudo splendor veritatis" - "Beauty is the splendor of truth"[75] - and unequivocally states that "<u>it cannot be doubted that there</u>

actually is this perfectly immediate recognition, this shuddering before the beautiful, of which Plato speaks in the Phaedrus [emphasis added],"[76] and Plotinus in his own works.

Of course, the artist does not, and cannot, replicate in physical fashion those profound basic structures, in which the mind must be grounded, a mind using as a compass the central order; as Heisenberg says, they do not exist physically, but in the region lying behind the physical. Of course, the structures are manifested in the world, but, as Plato said of beauty, the man who is truly awake is the "man who believes in beauty itself, and can distinguish it from the things which partake in it, who does not believe that the things with beauty to be beauty, or beauty to be those things."[77] Hence, the artist's purpose is the illumination of the basic structures in the soul: "The artist tries by his work to make these [eternal features of the world] understandable," particularly in the experiential way of above.[78] Yet, in what manner can it be said that art illumines the forms? It would appear that, for the physicist, art images those basic structures. For example, a material triangle is not the ideal Triangle; however, that basic structure is best described through the language of geometry, where the triangle is an image of the Triangle. In like manner, the basic structure uncovered by the artist cannot be duplicated; rather, it must be imaged. As he says, "Those who have thought about Plato's philosophy will know that the world is shaped by images,"[79]

and the term 'image' seems to be close to what the physicist means when he describes art as "always an idealization,"[80] in the sense of the Platonic Ideas. Although Heisenberg never directly refers to the great Meister Eckhart, since the two are of similarly inclined minds, it is perhaps helpful to use Eckhart's insights here:

> An image is not of itself; nor is it for itself. It has origins in that of which it is the image. To that it belongs properly with all that it is. It does not belong to what is foreign to its origin, nor does it owe anything to this. An image receives its being immediately from that of which it is an image. It has one being in it and it is the same being.[81]

It is in this way, it would seem, that art can be called the 'imaging' of the basic structures. It is not the basic structure, but receives its being from it, and thus shares it. One can only come to an understanding of those structures through those accessible things that share in it. Hence art as idealization: "the ideal is different from reality - at least from the reality of the shadows, as Plato would have put it - but idealization is necessary for understanding."[82]

Given the immense effort of 'seeing, knowing, sensing and believing' required for the discovery of the form, that much effort will be necessary on the artist's part to illuminate it. In this respect, Aquinas' contention, that the existence of the One can never be proven, due not to a lack of clarity, but an excess of clarity, comes to mind. The Ideas with which art is concerned are those with which religion is concerned; recall that, for Heisenberg, the artist is compelled to

'create' out of a religious concern for the human relatedness to the central order. The concepts of natural language (e.g. the mind, the soul, God, etc.), as opposed to the concepts of scientific language, are "formed by the immediate connection with reality; they represent reality,"[83] that is, the reality of the ideal. Thus, the basic structures there initiated can be said to be characterized by this 'excess of clarity'; as such, their elucidation necessitates the use of a language which corresponds to that 'abundance' of clarity, language that calls one to feel, see and sense the rich basic structures. It is at this point that the mode of artistic discovery parts ways with that of scientific discovery, since there exists a crucial difference between the language of art and that of science; this difference accounts for the fact that the structures revealed by art are distinct from those revealed by science, and of a much more complex and profound nature.

Actually, it should be emphasized that Heisenberg does not consider the languages completely separate, and this is precisely where he sees possible danger. Unless one realizes that, although it is essentially the same language, science works with one level of it, and art with another, grave problems will arise. For Heisenberg, the scientific language, the basis of which is logic, as initially established by Aristotle, consciously attempts to concentrate on "very special structures, unambiguous connections between premises

and conclusions, [and] simple patterns of reasoning;"[84] further, Heisenberg considers mathematics to be a level of language emerging from this process of scientific clarification. Hence, the language and concepts of science are abstractions - almost compressions - and thus not immediately connected with reality; yet, once the limits of that language have been understood, it proves extremely beneficial in the specialized study of our relationship to nature. Nonetheless, Heisenberg is alarmed that the popularity of precise scientific concepts and language may detract from the truths of natural language, which proceed from religion, philosophy, and art, by either demanding the same precision in them, or ignoring them altogether. The fact is, it is possible to speak this scientific language in connection with the world outside a specialized study of nature, just as it is possible to speak English to a Greek; the question is, does the Greek understand, and can he answer our questions?

To play with this image for a moment, let us assume that the Greek knows a little English, and can very haltingly answer questions that he has (hopefully) understood. In response to our question, he tells that he lives on an island. Curious, knowing that the waters near our own home are rather polluted, we ask if he has the same problem. He has trouble with the word 'pollution' (he has never been to Athens), and so we get it across to him that our water is dark and dirty. No, he answers, the water surrounding his home is blue. We

register the color. But what he cannot get across to us is this azure experience of the ocean, where dazzling-colored fish will swim alongside one. We ask him if it is always very hot on his island, and he informs us in his broken English that in winter it does get cold. We try to tell him of the unbelievable cold of a Manitoba winter day, but the simple words which we must use to allow him to understand us simply cannot convey our suffering. And even if he spoke fluent English, it is quite doubtful that he could entirely understand the cold; although he may approach it through language, it is truly something that must be experienced to be understood. The same applies if we spoke fluent Greek: he might be able to describe the beauty of the ocean in which his island sits, and try to convey the temperatures that are heaven to a Manitoban, but it simply must be experienced to be understood. Nonetheless, one on either side would require the fluency to extend the invitation to visit and experience (of course, this illustration only works if one thinks of the two languages as levels of a single language).

It is true that the modern world has insisted on speaking the scientific language to the almost total exclusion of all others. Heisenberg rightly notes that the widespread trend in the last few centuries has been towards an increasing confidence in the scientific method and rationalism, leading to "a general skepticism with regard to those concepts of natural language which do not fit into the closed frame of

scientific thought - for instance, those of religion,"[85] especially those expressed through the language of art. In the context of our discussion, we might say that world doubts the existence of that 'azure experience.' The level of language which we apply to the wider realm does not possess the fullness in which that experience could be illuminated; our questions may be answered, but the answers themselves will be incomplete: "if we begin by neglecting many important aspects in favour of the one feature whereby we are able to order the phenomena, we are confining ourselves to the working out of a basic structure, a sort of skeleton, which only the addition of a great wealth of further details could turn into a genuine picture."[86] The structures which art is trying to illustrate call for the use of a language replete with the meaning that scientific language has removed for a special purpose:

> ...for instance, a secondary meaning of a word which passes only vaguely through the mind when the word is heard may contribute essentially to the content of a sentence. The fact that every word may cause many only half-conscious movements in our mind can be used to represent some part of reality in the language much more clearly than by the use of logical patterns. Therefore, the poets have often objected to this emphasis in language and in thinking on the logical pattern, which - if I interpret their opinions correctly - can make language less suitable for their purposes.[87]

Heisenberg cites Goethe's dissatisfaction with the scientific language (as he finds it in Goethe's Faust): "College logic," says Mephistopheles, shackles the mind's spontaneous acts, convincing the student that those acts now require a process -"one, two, three!"[88] In actuality,

however, the mind does not work through this restrictive logical sequence; rather,

> In truth the subtle web of thought
> Is like the weaver's fabric wrought,
> One treadle moves a thousand lines,
> Swift dart the shuttles to and fro,
> Unseen the threads unnumber'd flow,
> A thousand knots one stroke combines.[89]

Yet, continues Mephistopheles, scholars prize only the language of logic, of which use in the course of study drives out the "living spirit" from anything to which it is applied. The language stripped of its richness has not the power to move the mind, to draw it to the recognition of more complex structures.

Heisenberg, of course, is in entire agreement. There is a purpose to that scientific language, a language which makes intelligible certain structures of nature, but which may be unproductive in other realms if one does not ascend from there to a different level. With Goethe, Heisenberg holds that in the attempt to illustrate, to image the basic structures of value, rather than order (although value is itself an order of a more ineffable kind), the artist must utilize a richness and depth that the language of science does not possess; only through the language of art can one 'feel, see and sense' those particular eternal features of the world. That language somehow brings out those half-conscious structures in the souls of the audience, and makes that living spirit understandable in the most penetrating sense. Recall the unveiling of the structures through the Chaconne. The

inexpressibility of transformation through the language of music, inexpressible at least in the objectifiable statements associated with experimental science, resulted in Heisenberg's life-long confidence in the ways and aim of religion. It is apparent that he agrees with Bohr's statement, "The fact that religions through the ages have spoken in images, parables, and paradoxes means simply that there are no other ways of grasping the reality to which they refer. But that does not mean that it is not a genuine reality."[90] Plato is Heisenberg's great example. After attempting as far as possible to approach the One through precise scientific language, Heisenberg points out that Plato then switched to the language of poetry, "which evokes in the hearer images conveying understanding of an altogether different kind."[91] It is not so much that different words are used, but those words are now allowed to radiate with meaning, with ascending force.

For example, let us return to unfolding of the basic structures in architecture. Heisenberg notes that the mathematical principles were themselves derived from questions about the world around us: "geometry, for instance, was designed for measuring agricultural land."[92] However, those uncovered structures, say the semi-circle and rectangle of the earlier example, in Romanesque architecture, themselves contained the possibility for a rich unfolding and development. But the question posed by that particular style

of architecture was not the measuring of land; it can almost be said to have asked 'how great is God's glory?' Thus, a Romanesque cathedral is much more than those unfolded geometrical structures: it is, through the artistic subordination of all details to a uniform system, a declaration that God's glory is greater than all. There is poetry in that architecture, poetry that raises the mind upward to the Ideas, but only if the cathedral is understood as a rich whole, that 'word to move a thousand lines'. It is not a duplication of God's glory, but serves to illuminate it.

This same cathedral can also serve to re-illustrate Heisenberg's contention that the spiritual ascension through art is not one into a state of dream-like existence. Recall that the aim of religion is the discovery of one's relation to the central order, where 'order' is the physicist's constant emphasis. The movement from rationally understood order is not one into a realm of irrational fantasy, but one into ultra-rational order. Figuratively speaking then, the unveiling of the Idea of God's glory through the construction of the cathedral requires an immense regard for order, not only from the master architect, but all those who are involved in the project. Hence, the physicist notes that "when a great cathedral was to be built in the Middle Ages, many master masons and craftsmen were employed. They were imbued with the idea of beauty posited by the original forms, and were

compelled by their task to carry out exact and meticulous work in accordance with these forms."[93] In this case, the idea of beauty within the forms is that of God's glory, which could only be brought out with precise and painstaking work in accordance with the forms.

Additionally, Heisenberg uses this example in a very concrete way to demonstrate the necessary participation of the whole of humanity in the quest to discover our relation to that central order: everyone has their part to play, and the end result depends on the conscientious execution of their work:

> Perhaps it may be said in general that by means of the underlying structures...guidelines were drawn or even standards of value set up, whereby it could be objectively decided whether a given task had been well or ill discharged. It is the very fact that specific requirements have been laid down, that the individual can assist by small contributions in the attainment of large goals and that the value of his contribution can be objectively determined, which gives rise to the satisfaction proceeding from such a development for the large number of people involved.[94]

That is, the possibility to be realized influences the course of events;[95] thus, there is a real ethical and social aspect to art and architecture, an aspect which is also very much a part of the most positive science and technology. For example, noting that the development of science and technology has developed the Idea of the airplane (and keeping in mind that the rationally formulable ideas are different from the Platonic Ideas), Heisenberg points out that -

> the individual technician who assembles some component for such a plane, the artisan who makes it, knows that

> his work calls for the utmost care and exactitude, and that the lives of many may well depend on its reliability. Hence he can take pride in a well-executed piece of work, and delights, as we do, in the beauty of the aircraft, when he feels that in it the technical goal has been realized by properly adequate means.[96]

Of course, this particular example merely illustrates the relation of the many to a very specific one. Heisenberg's ultimate concern is with that over-arching superstructure, mentioned in the previous section, which lends meaning to each individual event. This is the central order, which contains all the orders within it, the orders of nature and value, and which sets the ultimate standards by which it is to be realized. In a discussion of the basic symmetries of which he is convinced matter is simply a manifestation, he uses an example that deliberately calls to mind the structure of the central order:

> One finds structures so linked and entangled with each other that it is really impossible to make further changes at any point without calling all the connections into question. We are reminded here of the artistic ribbon decorations of an Arab mosque, in which so many symmetries are realized all at once that it would be impossible to alter a single leaf without crucially disturbing the connection to the whole.[97]

These decorations, understood as the basic structures, set in complex and intricate order, express for Heisenberg not only the spirit of the religion from which they have arisen, but the spirit of his own religious understanding. His constant call to "bear the wider connections in mind"[98] when approaching any task, or making any decision, must be understood in this framework. One's duty (if not one's

salvation) is the realization of that superstructure, as it is imaged in oneself; only through this realization will one be able to act in accordance with it. Of course, and paradoxically, it is only by acting in accordance with the standards of the central order that one can realize it. Hence, the realization of the one is very much a lived process, since it comes through action, just as in art, wherein the structures are revealed only through material expression. Human action does go beyond art, but, assuming that art is indeed an avenue of religious understanding, human action is based upon the insights of art: the structures unfold through that medium into ourselves, yet still are not able to shine unless they are actuated by ourselves. Again, it may not be incorrect to say that Heisenberg thinks of action as a third and highest level to our language, but this will be discussed at the appropriate time. For the moment, it is enough to say that art acts as a springboard to this crucial stage, and only art. Although it is possible to realize the structures of natural order through science, and Heisenberg sees this as science's task, he is adamant that science simply does not have the power to bring out those structures of value in the soul, those structures which guide our human action.

To say that this poses a problem for the contemporary world is an incredible understatement. The predominance of scientific language has been discussed above, and Heisenberg noted with alarm that that language is not appropriate to the

task of filling out the whole picture. Yet, if it was merely a problem of language, the situation would not be nearly so dangerous as it has become. Rather, Heisenberg sees a real evil in the present situation, where evil, as we have noted, is the elevation of a partial order over the central. In this case, that evil is associated with the elevation of science and technology, though Heisenberg would insist that it is not synonymous with the two. The physicist would never maintain that science and technology are in themselves evil; understood in the wider context, they are good (recall that the main thesis here rests on Heisenberg's understanding of science as an avenue of religious understanding). Unfortunately, even a partial good may be transformed into evil if the wider connections are ignored.

In the modern age, science and technology go hand in hand. Much of science could not have been achieved without the advance of technology, and much of technology could not have advanced without the deeper understandings reached by science, particularly a science which rested on mechanical processes. Unfortunately, technological progress has blindly followed the Baconian directive, as science is also unhappily wont to do, and Heisenberg observes in modernity the ancient mode of understanding, in the resolution of the "one" and the "many", connected to that directive, as the cathedral craftsmen were connected to the idea of the glory of God:

> Just as science subordinates every detailed question to the great task of understanding nature as a whole, so

> even the smallest technical advance serves the general aim of extending man's material powers. The value of this aim is questioned just as little as scientists question the value of an understanding of nature. Both aims become fused into the common-place slogan, 'knowledge is power'.[99]

The slogan is not evil in itself: knowledge is power, and we have been given the power to accomplish many wonderful things. As Bacon had predicted, the imitation of nature has allowed us to assume some control. In medicine, Heisenberg recognizes that "the doctor can free the patient from his suffering only if he knows and utilizes the biological laws that govern the workings of the organism."[100] Further, this principle of imitation is at the heart of the development of the machines of modernity; if the mechanistic view of science can be said to be the idea, then technology can be said to be a manifestation of that idea, that is, technology is "the machine". Again this is not evil; machines are very useful. But that is all that they are, and here lies the danger.

Although important, the detailed discussion of Newtonian science will be left to the next section, where it is related to specific problems; its method, assumptions, and claims to 'absolute truth' - its immodesty ["Unbescheidenheit"] - was as much an obstacle for further scientific discovery as it was/is for the serious consideration of art.[101] All that need be said for the moment is the obvious: the mechanistic/materialistic science of modernity exceeded its bounds, and claimed all of reality as its dominion. Its language began to be applied to diverse areas, and that

application was soon understood not as throwing fresh light on the other areas, but as throwing the only light upon them; again, it must be kept in mind that, for the most part, that light was in the service of knowledge and power, and so technology and science urge each other forward. "The world governed by Newtonian science, which Goethe hoped to stay clear of, has thus become our reality, and it is no help at all to us to be reminded that Faust's partner has also a hand in the game here. We have to put up with it, as we always had to do."[102] That is, there is a real evil in the situation, as the possibility of evil exists in every situation. But evil, as mentioned earlier, albeit a partial order, is in fact an order, and necessarily possesses dynamic form. Heisenberg quotes Goethe, "'The growing prevalence of machines distresses and worries me. It is rolling up like a storm, slowly, slowly. But it has taken its course, it will come, and it will strike.'"[103]

It is not so much the machines that Heisenberg finds ominous, but their effect on humanity. To illustrate the unfortunate situation, Heisenberg relates the wisdom of Chang-Tzu, who tells of a passer-by who advises an old man to use a mechanical draw-well to irrigate his vegetable garden, rather than the manual method he was using, since it involved too much work for the meagre results; the old man became angry at this advice, and said:

> I have heard my teacher say that whoever uses machines does all his work like a machine. He who does his work

> like a machine grows a heart like a machine, and he who carries the heart of a machine in his breast loses his simplicity. He who has lost his simplicity becomes unsure in the strivings of his soul. Uncertainty in the strivings of the soul is something which does not agree with honest sense. It is not that I do not know of such things; I am ashamed to use them.[104]

Heisenberg recalls Goethe's complaint that this 'uncertainty', particularly with regards to nature, was due to the abstraction of modern science, which would consider only a small, mechanical facet of nature, and Goethe would certainly hold with Chang-Tzu that the uncertainty derived from this view of nature 'does not agree with honest sense.' It goes without saying at this point that Heisenberg was well aware that it did not; science consciously confined itself to a small portion for a special purpose. But that "uncertainty in the strivings of the soul" ("Ungewißheit in den Regungen des Geistes") characterizes for Heisenberg the crisis of modernity, a crisis he is convinced was precipitated by that overarching mechanistic/materialistic structure, where the possibility to be realized influences the course of events; for the most part, that possibility is utility, and little more. He refers to modernity as "the cult of utility" ("das Streben nach Zweckmäßigkeit"),[105] and it is true that most things in the world today are required to be useful. This is the partial order that has broken away and elevated itself over the central; what makes it worse is its utter meaninglessness.

Heisenberg clarifies this: "utility as such is not a value in itself but merely shifts the question of value one place over, to the further question: is there any value in the purpose to which the knowledge and powers in question are applied and which they are meant to serve?"[106] Heisenberg concedes Goethe's perception that this view of nature agreed with the "wealth and rapidity" which "the world admires and what everyone strives to attain;"[107] utility can be harnessed to sheer self-interest. Yet, it also agreed with the modern medicine's eradication of plagues, saving lives, sparing suffering; at the same time, a population explosion due to the advances of modern medicine threatens to end in "frightful catastrophes."[108] In answering, then, the above question, Heisenberg is clear that "[it] can be decided only in light of the value concepts that men choose to be guided by in the setting the goals. But these ideas cannot come from science itself; at all events, that is not where they come from meanwhile."[109] That is, there is simply no possible way to extract guiding ideals from science and technology, especially when they serve the principle of utility; they must come from elsewhere. Wealth and rapidity are not consequences of the mechanistic view, nor is spiritual progress. Utility is simply a means to an end, not an end in itself, as the modern world has mistakenly assumed. In the following passage, Heisenberg's illustration of the problem here is poetically enlightening (most appropriately for this section):

> In what appears to be its unlimited development of material powers, humanity finds itself in the position of a captain whose ship has been built so strongly of steel and iron that the magnetic needle of its compass no longer responds to anything but the iron structures of the ship; it no longer points north. The ship can no longer be steered to reach goal, but will go around in circles, a victim of wind and currents. However, the danger persists only so long as the captain has not grasped that the compass is not responding to the magnetic forces of the earth. The moment he realizes that the danger is as good as half-way removed; the captain who does not wish to sail in circles but wishes to reach a known or even unknown goal will find ways and means of determining the direction of his ship. He may use a modern compass which is not affected by the iron of the ship, or, as in olden times, he may use the stars as his guides. Of course, he cannot order the stars to be visible at all times, and perhaps it is true that in our age only a few of them seem to be shining at all, but this one thing is clear: the very realization that faith in progress must have a limitation involves the wish to cease going in circles and to reach a goal instead.
>
> As we become clearer about this limitation, the limitation itself may be considered to be the first foothold from which we may re-orientate ourselves.[110]

Nothing is more certain than the inability of the captain to order the stars to be visible, that he may sail with them as his guide, as in days of old: the established Newtonian worldview, convinced of its exclusive mode and possession of 'truth', does not allow the mode of understanding necessary to uncovering the structures of art and religion, from where those guiding principles emerge, if it allows the existence of those realms at all: "The great success of the scientific method, by trial and error, excludes in our own day any definition of truth that has not withstood the severe criteria of this method."[111] If any insights are claimed through these realms, they are considered 'subjective' rather than 'objective', a consideration akin to a death sentence in this

view. Of course, if no stars were shining at all, then Heisenberg could not say and think all that he does, and he is convinced that some will always shine: "that simplicity of heart of which that sage spoke has never been lost entirely. In the course of centuries, it may have dimmed at times and have grown stronger at others, but always it has re-emerged in all its fruitfulness."[112] This is, Heisenberg would say, the moment for re-emergence, and here science must play a crucial role. If Western humanity truly wants to reach a goal, then it must make use of that modern compass: although those limitations may be discerned through the few remaining stars, it is particularly important that they be demonstrated through science. In this Heisenberg agrees with Pauli:

> The development of science during the past two centuries has certainly changed man's thinking, even outside the Christian West. Hence it matters quite a bit what physicists think. And it was precisely the idea of an objective world running its course in time and space according to strict causal laws that produced a sharp clash between science and the spiritual formulations of the various religions. If science goes beyond this strict view...then the relationship between science and the contents religions try to express must change once again. Perhaps science, by revealing the existence of new relationships during the past thirty years, may have lent our thought much greater depth.[113]

In the next section, a great deal of attention will be paid to the realization that science has in fact gone beyond that strict view: although we have often, and rather glibly, spoken of Heisenberg's understanding that science is limited to special structures and relationships, this was an understanding arrived at by great effort through quantum

mechanics. And Heisenberg would assert without reservation that quantum physics has returned to our thoughts the depth lost in the mechanistic/materialistic worldview. However, it seems fair to say that science, as understood by Heisenberg, has only redeemed itself by taking as its own guide the compass of the central order. By doing so, it has come to a deep awareness of itself and its place in the overarching superstructure of the central order; at least Heisenberg sees it thus. That it has a place in that central order the physicist has no doubt: the truths that are realized there may be modest in the wider scheme of things, but are firmly founded. A real aspect of the central order has been realized. Nonetheless, "the space in which man develops as a spiritual being has more dimensions than the single one which it has occupied during the last centuries;"[114] even though science properly guided is rescued from the 'evil' of the partial Baconian order, science alone cannot reveal the entire structure of the central order. As made clear earlier, "the language of images and likenesses is probably the only way of approaching the 'one' from more general domains. If the harmony in a society rests upon a common interpretation of the 'one', the unitary principle behind the phenomena, then the language of poetry may be more important here than the language of science."[115]

Yet, there is no doubt that for the present time, that language depends on the ability of scientists to demonstrate

the need for its serious re-introduction into the world. Further, science does not only act as a foothold by which the art of olden days can be recovered. It has been emphasized many times that, for Heisenberg, the process of understanding through art must be a living one. It must address the concerns of the age. As discussed earlier, the art of the mid-twentieth century, in addressing too many concerns, addressed none. In Heisenberg's eyes, this can be attributed, first and foremost, to "the loss of that centre which Goethe strove all his life to preserve,"[116] a loss that affected all aspects of the modern world. Art, too, goes around in circles, not knowing what to speak about, nor of how it should be spoken. Of course, that loss of the central order translates into a very real break with religion, from where art takes both its spiritual and artistic vitality: "the present-day dissolution of old orders, e.g., of religious ties, is reflected in art in the dissolution of traditional forms, of which only particular abstract elements remain."[117] In a very real way, organized religion itself can be said to be affected by this loss of center, as churches in the last few hundred years have splintered into disconnected fragments of the whole. It appears that some churches either become too fixed on one aspect of the total faith, that elevation of a partial order, or refuse to acknowledge any established form or content at all, assured of their universal accessibility; the latter may be accessible, but one wonders whether it could lead to

anything of substance. The abstraction here, and in art, in not that of science, which has obtained through it "insight into very wide-ranging connections."[118] It is not abstraction at all; rather, speaking specifically of art, Heisenberg says that much of it today is "blurred, indeterminate art, or, as it frequently labels itself, an art of denial and dissolution."[119] Surely, the same can be said of some churches, where the religion is indeed blurred and indeterminate; their efforts to affirm and integrate too many concerns results in the denial and disintegration of most. However, as interesting as this line of speculation may be, particularly the use of science as a foothold for the spiritual recovery of organized religion, it is necessary to remain with our primary focus, which is very much connected to this possibility.

Since it is from a centrally-guided art that we must turn to recover in renewed form the standards and values which science cannot provide, Heisenberg refuses that this negative direction be overinflated by grandiose phrases, such as one that stated "'We have indeed, destroyed with our life plan the cultures of the world; but the dead still survives and works in the tissues of the living.'"[120] The statement inflames Heisenberg: "These strike me as words too grand for a bad business; and the same business was also a bad one for science. It needs the greatest efforts to find the way back into order from here."[121] Although Heisenberg himself seems

to have always approached science guided by the compass of the central order, the absolute need for that compass was brought intensely home to him and a great many other physicists when the atom bomb was dropped on Hiroshima. There is no grandiose phrase that can exalt the fact that "the progress of atomic physics in which I had participated in for twenty-five long years had now led to the death of more than a hundred thousand people."[122] Yet, if art does not make a genuine return to the concern with the human relatedness to the central order, such horrors can be expected to continue. Heisenberg is clear that this concern is our only hope: "If the magnetic force that has guided this particular compass [Christianity] - and what else was its source but the central order? - should ever become extinguished, terrible things may happen to mankind, far more terrible than concentration camps and atom bombs."[123] The world of art has a responsibility as great as, if not greater, that of science. Of this, Heisenberg has no doubt.

Of course, it is not that a centrally-guided art will be forced upon the world. The physicist is aware of a spiritual hunger in people, and he speaks of the "emptiness and suffering" ("die Leere und die Leiden") of the world: in all those irrational doings of this world "there is probably an unconscious expression of longing for that world in which mind is more than information, love more than sexuality and science more than the collection and analysis of empirical data."[124] Although Heisenberg's immediate experience of his relation to

the central order through music was immensely important to him, he could not remain alone with the beauty, with the splendor of the "one". Even as a youth, he realized the importance of beauty to all people, not in any dogmatic sense, but simply because people need to discover the beauty in their souls. This is particularly illustrated in an incident related by Heisenberg's wife, Elisabeth: as the people returned home from the first World War, a movement arose which had as its goal the participation of the workers and uneducated in the cultural riches of their country, a goal about which young Heisenberg was most enthusiastic. He gave to workers courses in astronomy, and took them on excursions outside the city to observe the night sky.[125] Art, not surprisingly, had a place in this enthusiasm: "On another occasion - later he was always to think of this as somewhat pretentious - he tried to initiate the workers into the beauty of the world of Mozart's operas."[126] This sense of obligation to the people, which comes out in many of his actions, is not an insincere one, but rather seems to stem from the conviction that religion is indeed the spiritual form of the community: "Heisenberg was deeply impressed by the openness and commitment of his students, who, for the most part, were people who had come back from the war starving for spiritual nourishment. For the remainder of his life he felt a special responsibility toward them."[127]

Heisenberg's great captivation by art, and his profound conviction that beauty, the splendor of truth, was there translucent, suggests quite clearly that, although no saint, he was a special individual indeed. His attempts to reveal the beauty of Mozart to those workers calls to mind the words of Thomas Traherne: "you never enjoy the world aright till you so love the beauty of enjoying it that you are covetous and earnest to persuade others to enjoy it."[128] One last time the insights of Plotinus are called upon, since he could here be describing Heisenberg himself:

> But there must be those who see this beauty by that with which the soul sees things of this sort, and when they see it they must be delighted and overwhelmed and excited much more than by those beauties we spoke of before, since now it is true beauty that we are grasping. These experiences must occur whenever there is contact with any sort of beautiful thing, wonder and a shock of delight and longing and passion and a happy excitement. One can have these experiences by contact with invisible beauties, and souls do have them, practically all, but particularly those who are more passionately in love with the invisible, just as with bodies all see them, but all are not stung as sharply, but some, who are called lovers, are most of all.[129]

It would seem fair to describe the scientist so, that is, as a lover of the central order, and the tradition to which Heisenberg was drawn would say that it is in lovers that the towering structures are revealed. Yet, though earnest to persuade others to enjoy the beauty he could see, he was quite aware of his obligation to continue the search for the beauty, for the truth, that he could not yet see. Asking where he could most contribute, he chose science, aware that it was on the track of "far more important structures" than was music at

the time. Yet, that genuine sense of obligation to his fellow humans continues, and throughout his scientific works, one can almost hear a young man, eagerly pointing out the stars and ingenuously playing Mozart, sharing with us the knowledge that here, too, is the experience of the central order.

NOTES TO CHAPTER TWO

1.Heisenberg, Physics and Beyond, p. 11; Heisenberg, Der Teil und das Ganze, p. 24: "Die klaren Figuren der Chaconne waren wie eine kühler Wind, der den Nebel zerriß und die scharfen Strukturen dahinter sichtbar werden ließ."

2.Heisenberg, Physics and Philosophy (New York: Harper & Brother Publishers, 1958), p. 63; Gifford lectures at University of St. Andrews, winter term, 1955-1956.

3.Heisenberg, Across the Frontiers, p. 168; Heisenberg, Schritte über Grenzen, p. 254: "Also müßte das Seiende ewig, einförmig, zeitlich und räumlich unbegrenzt gedacht werden."

4.Heisenberg, Physics and Beyond, p. 33; Heisenberg, Der Teil und das Ganze, p. 53: "Das Zurückführen der bunten Vielfalt auf das Allgemeine und Einfache..."

5.Heisenberg, Across the Frontiers, p. 167; Heisenberg, Schritte über Grenzen, p. 253: "[Die Schönheit ist] als die richtige Übereinstimmung der Teile miteinander und mit dem Ganzen."

6.Ibid., p. 168; Heisenberg, Shritte über Grenzen, pp. 253-254: "Wir erkennen, daß die einzelnen Teile zusammenpassen, daß sie eben als Teile zu diesem Ganzen gehören, und wir empfinden die Geschlossenheit und Einfachheit dieses [...Systems] ohne jede Reflexion als schön."

7.F.M. Cornford, Before and After Socrates (Cambridge: Cambridge University Press, 1965), p. 67.

8.Ibid., p. 68.

9.Heisenberg, Across the Frontiers, p. 170; Heisenberg, Schritte über Grenzen, p. 257: "Denn wenn das Schöne als Übereinstimmung der Teile untereinander und mit dem Ganzen erkannt wird und wenn andereseits alles Verständnis erst durch diesen formalen Zusammenhang zustande kommen kann, so wird das Erlebnis des Schönen fast identisch mit dem Erlebnis des verstandenen oder wenigstens geahnten Zusammenhangs."

10.Ibid., p. 171; Heisenberg, Schritte über Grenzen, p. 257: "Das Erfassen der Ideen durch den menschlichen Geist ist, wie schon ihr Name sagt, mehr ein künstlerisches Schauen, ein halbbewußtes Ahnen als ein verstandesmäßiges Erkennen. Es ist eine Wiedererinerung an Formen, die dieser Seele schon vor ihrem Erdendasein eingepflanzt worden sind."

11."What is that which gleams through me and strikes my heart without hurting it; and I shudder and I kindle? I shudder inasmuch as I am unlike it; I kindle as much as I am like it. It is Wisdom, Wisdom's self, which gleameth through me." Confessions, trans. by Vernon J. Bourke (Washington: Catholic University of America Press, Inc., 1953), XI, 11.

12.Heisenberg, "Tradition in Science," Dialogue, vol. 7, no. 1, 1974, p.51.

13.Harmony of the World, cited in Across the Frontiers, p. 178.

14.Ibid., p. 136; Heisenberg, Schritte über Grenzen, p. 221, "Das Wort 'Idee' [hat] eine etwas zu subjektive Färbung...erhalten."

15.Heisenberg, Physics and Beyond, p. 214; Heisenberg, Der Teil und das Ganze, p. 291: "Natürlich wissen wir, daß für uns die Wirklichkeit von der Struktur unseres Bewußtseins abhängt; der objektivierbare Bereich ist nur ein kleiner Teil unserer Wirklichkeit. Aber auch dort, wo nach dem subjektiven Bereich gefragt wird, ist die zentrale Ordnung wirksam und verweigert uns das Recht, die Gestalten dieses Bereichs als Spiel des Zufalls oder der Willkür zu betrachen."

16.Ibid., p. 216; Heisenberg, Der Teil und das Ganze, p. 293: "[Ich habe das Wort 'Seele' gebraucht...] Weil das Wort 'Seele' eben hier die zentrale Ordnung, die Mitte bezeichnet bei einem Wesen, das in seinen äußeren Erscheinungsformen sehr mannigfaltig und unübersichtlich sein mag."

17.Heisenberg, Across the Frontiers, p. 171; Heisenberg, Schritte über Grenzen, p. 268: "In dem Momement..., in dem die richtigen Ideen auftauchen, spielt sich in der Seele dessen, der sie sieht, ein ganz unbeschreiblicher Vorgang von höchster Intensität ab. Es ist das staunende Erschrecken, von dem Plato im 'Phaidros' spricht, mit dem die Seele sich gleichsam an etwas zurückerinnert, was sie unbewußt doch immer schon besessen hatte."

18.Plato, The Republic, trans. by W. H. D. Rouse, ed. by E. Warmington and P. Rouse (New York: Mentor Books, 1956), p. 308.

19.Heisenberg, Across the Frontiers, p. 171; Heisenberg, Schritte über Grenzen, p. 257: "Die zentrale Idee ist die des Schönen und Guten, in der das Göttliche sichtbar wird und bei deren Anblick die Flügel der Seele wachsen."

20.Ibid., p. 182; Heisenberg, Schritte über Grenzen, p. 268: "Denn, so hieß es bei Pauli, jedes Verstehen ist ein landwieriger Prozeß, der lange vor der rationalen Formulierbarkeit des Bewußtseinsinhalts durch Prozesse im Unbewußten eingeleitet wird."

21.Ibid., p. 178.

22.Ibid., p. 180; Heisenberg, Schritte über Grenzen, p. 266: "Auf dieser Stufe sind an Stelle von klaren Begriffen Bilder mit starken emotionalem Gehalt vorhanden, die nicht gedacht, sondern gleichsam malend geschaut werden. Insofern diese Bilder ein Ausdruck für einen geahnten, aber noch unbekannten Sachverhalt sind, können sie entsprechend der von C. G. Jung aufgestellten Definition des Symbols auch als symbolisch bezeichnet werden."

23.Ibid.; Heisenberg, Schritte über Grenzen, p. 267: "Natürlich gehört es zum Wesen dieser Urbilder, daß man sie nicht eigentlich rational oder etwa gar anschaulich beschreiben kann."

24.Ibid., p. 182; Heisenberg, Schritte über Grenzen, p. 268: "Die Archetypen funktionieren als die gesuchte Brücke zwischen den Sinneswahrnehmungen und den Ideen."

25.Heisenberg, Physics and Philosophy, p. 180.

26.Heisenberg, Physics and Beyond, p. 186; Heisenberg, Der Teil und das Ganze, p. 254: "Aber wir bedenken nicht, daß Verwirklichen ja gerade bedeutet, sich dem Zwang der Gesetzmäßigkeit unterzuordnen."

27.Ibid.; Heisenberg, Der Teil und das Ganze, p. 252: "...auch das, was wir hier vor uns sehen, sind ja Tatsachen..."

28.Heisenberg, Across the Frontiers, p. 71; Heisenberg, Schritte über Grenzen, p. 152: "Das Herausheben eines Merkmals, das in diesem Zusammenhang als besonders wichtig betrachtet wird gegenüber allen anderen Eigenschaften, macht das Wesen der Abstraktion aus."

29.Heisenberg, Across the Frontiers, p. 148; Heisenberg, Schritte über Grenzen, p. 233: "Die Kunst hat wohl zu allen Zeiten den Geist, den Lebensgrund, das Lebensgefühl der betreffenden Epoche dargestellt."

30.Heisenberg, Physics and Philosophy, p. 109.

31.Heisenberg, Across the Frontiers, p. 147.

32.Ibid., 72; Heisenberg, Schritte über Grenzen, p. 153: "Sie erweisen sich als viel reichhaltiger und fruchtbarer, als man ihnen zunächst ansehen kann. Sie zeigen in der späteren Entwicklung eine selbständig ordnende Kraft, indem sie zur Bildung neuer Formen und Begriffe Anlaß geben, Erkenntnisse über deren Zusammenhang vermitteln und sich auch bei dem Versuch, die Welt der Erscheinungen zu verstehen, in irgendeinem Sinne bewähren."

33.Ibid., p. 147; Heisenberg, Schritte über Grenzen, p. 233: "Das Nichtvorhandensein von bestimmten Formen kann...niemals eine Kunst oder eine Wissenschaft wirklich charakterisieren; denn es gehört ja zum Wesen dieser geistigen Bemühungen, Inhalte zu gestalten, also Formen zu bilden."

34.Heisenberg, Physics and Beyond, p. 187; Heisenberg, Der Teil und das Ganze, p. 255: "Sobald es die Form sprengt, führt der Weg ins Chaos, so wie wir es hier vor uns sehen..."

35.Heisenberg, Across the Frontiers, p. 147; Heisenberg, Schritte über Grenzen, p. 232: "Dieses Wechselspiel oder, wenn man so will, dieser Kampf zwischen dem Ausdrucksinhalt und der Beschränktheit der Ausdrucksmittel scheint mir - ähnlich wie in der Wissenschaft - die unumgängliche Voraussetzung dafür, daß wirkliche Kunst entsteht. Wenn kein Inhalt zur Darstellung drängt, so fehlt der Boden, auf dem die Kunst wachsen kann; wenn die Beschränktheit der Ausdrucksmittel wegfällt, wenn man z.B. in der Musik jeden beliebigen Klang hervorbringen kann, so gibt es diesen Kampf nicht mehr, so stößt die Anstrengung der Künstler gewissermaßen ins Leere."

36.Ibid.; Heisenberg, Schritte über Grenzen, p. 232: "Es ist bekannt, daß spezielle Richtungen der modernen Kunst durch die Negation bestimmter Formen definiert werden; man spricht von 'atonaler' Musik oder von 'nichtgegenständlicher' Malerei. Es wird also hier nicht vom Inhalt geredet, und von der Form nur in der Negation."

37.Ibid., p. 148; Heisenberg, Schritte über Grenzen, p. 232: "Es sieht also bei der modernen Kunst im Gegensatz zur modernen Naturwissenschaft manchmal so aus, als sei der Inhalt selbst, der darstellt werden soll, noch umstritten oder ungreifbar."

38.Ibid.; Heisenberg, Schritte über Grenzen, p. 233: "...für das Wie gibt es eher zu viele als zu wenige Antworten."

39.Ibid., 150; Heisenberg, Schritte über Grenzen, p. 235: "...daß die Tendenz zur 'Entstaltung' aus einem Lebensgefühl stammt, das nicht nur die Unzuverlässigkeit aller bisherigen Formen zu spüren glaubt, sondern das auch hinter den Formen Zusammenhänge ahnt, die vielleicht später das Leben wieder tragen können. Möglicherweise ist dies der wichtigste Inhalt moderner Kunst."

40.Ibid., 152; Heisenberg, Schritte über Grenzen, p. 238: "Obwohl es sich am Ende um neue Gestaltung und das Bilden neuer Formen handelt, können die neuen Formen nur aus dem neuen Inhalt entstehen; es kann nie umgekehrt gehen. Neue Kunst machen, heißt also, so würde ich vermuten, neue Inhalte sichtbar oder hörbar machen, nicht nur neue Formen erfinden."

41.Ibid.; Heisenberg, Schritte über Grenzen, p. 237: "Denn nur dort, wo uns das Neue vom Problem selbst aufgezwungen wird, wo es gewissenmaßen von außen, nicht von uns, kommt, hat es später die Kraft zu verwandeln."

42.Heisenberg, Physics and Philosophy, p. 108.

43.Heisenberg, Across the Frontiers, p. 86; Heisenberg, Schritte über Grenzen, p. 168: "...daß man solche Grundformen nicht erfinden, sondern nur entdecken kann. Die Grundformen besitzen eine echte Objektivität."

44.Ibid., p. 175; Heisenberg, Schritte über Grenzen, p. 262: "Aus diesen Grundformen entstehen im Laufe der Geschichte neue, kompliziertere, auch veränderte Formen, die doch irgendwie als Variationen zum gleichen Thema aufgefaßt werden können, und so entfaltet sich aus den Grundstrukturen eine neue Weise, ein neuer Stil des Bauens. Man hat das Gefühl, daß diesen ursprünglichen Formen doch die Entfaltungsmöglichkeiten schon zu Beginn angesehen werden können; denn sonst wäre es kaum verständlich, daß viele begabte Künstler sich sehr schnell entschließen, diesen neuen Möglichkeiten nachzugehen."

45.Ibid., p. 72; Heisenberg, Schritte über Grenzen, p. 153.

46.Ibid., p. 139; Heisenberg, Schritte über Grenzen, p. 224.

47.Ibid., pp. 170-171; Heisenberg, Schritte über Grenzen, p. 257: "...und, so wären wir heute versucht fortzusetzen, diese idealen Gestalten sind wirklich, weil und insofern sie im materiellen Geschehen 'wirk'sam werden."

48.Ibid., p. 136; Heisenberg, Schritte über Grenzen, p. 221: "[Sie ist] die Urform, die Grundstruktur, das gestaltende Prinzip der Pflanze..."

49.Ibid., p. 139; Heisenberg, Schritte über Grenzen, p. 224: "...eine formgebende Kraft..."

50.Plotinus, Enneads, I, 6, (3), in The Essential Plotinus, ed. and trans. by Elmer O'Brian (New York: Mentor Books, 1964).

51.Heisenberg, Across the Frontiers, p. 136; Heisenberg, Schritte über Grenzen, p. 221: "Aber obwohl dieses Urphänomen nicht ein Grundsatz sein soll, aus dem man die verschiedenartigen Phänomene herzuleiten hätte, sondern eine Grunderscheinung, innerhalb deren das Mannigfaltige anzuschauen ist..."

52.Enneads III, 7, as cited, with slight changes in the translation, by K. Klostermaier in an unpublished paper "Time and Eternity," from Plotinus, A.H. Armstrong (London: William Heinemann, Ltd., 1967).

53.Heisenberg, Physics and Philosophy, p. 125.

54.Ibid.

55.Ibid., p. 108.

56.**Across the Frontiers**, p. 73; Heisenberg, Schritte über Grenzen, p. 154: "Bei dem Versuch, in dieser Weise die Geometrie auf die Zahlenlehre zu begründen, sind schon die Pythagoreer auf die Schwierigkeit mit den irrationalen Streckenverhältnissen gestoßen und so zur Erweiterung ihres Zahlkörpers gedrängt worden; sie mußten gewissermaßen den Begriff der Irrationalzahl erfinden. Von hier weiterschreitend gelangten die Griechen zum Begriff des Kontinuums und zu den bekannten, später vom Philosophen Zenon studierten Paradoxien. Auf die Schwierigkeiten in dieser Entwicklung der Matematik soll aber hier nicht eingegangen, es sollte nur auf den Reichtum an Formen hingewiesen werden, der im Zahlbegriff implizite steckt und aus ihm entfaltet werden konnte."

57.Heisenberg, Physics and Philosophy, p. 108.

58.Heisenberg, Physics and Beyond, p. 209; Heisenberg, Der Teil und das Ganze, p. 284: "'Nur die Fülle führt zur Klarheit, und im Abgrund wohnt die Warheit.' Die Fülle ist hier nicht nur die Fülle der Erfahrung, sondern auch die Fülle der Begriffe, der verschiedenen Arten, über unser Problem und über die Phänomene zu reden."

59.Ibid., p. 102; Heisenberg, Der Teil und das Ganze, p. 143: "Das Gegenteil einer richtigen Behauptung ist eine falsche Behauptung. Aber das Gegenteil einer tiefen Wahrheit kann wieder eine tiefe Warheit sein."

60.Ibid., p. 136; Heisenberg, Der Teil und das Ganze, p. 189: "So bodenlos ist eben dieses ganze Streben nach Erkenntnis."

61.Ibid., p. 89; Heisenberg, Der Teil und das Ganze, p. 125: "Daher scheint es mir auch durchaus begreiflich, daß über den Inhalt der Religion nicht in einer objecktivierenden Sprache gesprochen werden kann. Die Tatasche, daß verschiedene Religionen diesen Inhalt in sehr verschiedenen geistigen Formen zu gestalten suchen, bedeutet dann keinen Einwand gegen den wirklichen Kern der Religion. Vielleicht wird man diese verschiedenen Formen als komplementäre Beschreibungsweisen auffassen sollen, die sich zwar gegenseitig ausschließen, die aber erst in ihrer Gesamtheit einen Eindruck von dem Reichtum vermitteln, der von der Beziehung der Menschen zu dem großen Zusammenhang ausgeht."

62.Heisenberg, Physics and Philosophy, p. 92.

63.Heisenberg, Physics and Philosophy, p. 108.

64.Heisenberg, Physics and Beyond, p. 23; Heisenberg, Der Teil und das Ganze, p. 40: "Alles, was nicht mit vollem Einsatz gemacht ist, wird sowieso vergessen und verdient nicht, auch nur erwähnt zu werden."

65.Heisenberg, Across the Frontiers, p. 132; Heisenberg, Schritte über Grenzen, p. 216: "Das 'unum, bonum, verum', das 'Eine, Gute, Wahre' war für ihn wie für die alten Philosophen der einzig mögliche Kompaß, nach dem die Menschheit sich beim Suchen ihres Weges durch die Jahrhunderte richten konnte."

66.Ibid., p. 133; Heisenberg, Schritte über Grenzen, p. 218: "Diesem Inhalt des Naturerlebnisses muß sich, so glaubt Goethe, auch die wissenschaftliche Methode anpassen, und so ist Suchen nach dem Urphänomen aufzufassen als das Forschen nach jenen der Erscheinung zugrunde liegenden, von Gott gesetzten Strukturen, die nicht nur mit dem Verstande konstruiert, sondern unmittelbar geschaut, erlebt, empfunden werden können."

67.Ibid., tr. E. A. Bowring; cited by Heisenberg, in Schritte über Grenzen, p. 218:

Gott auf seinem Throne zu erkennen,
ihn den Herrn des Lebensquells zu nennen,
jenes hohen Anblicks wert zu handeln
und in seinem Lichte fortzuwandeln.

68.Ibid.; Heisenberg, Schritte über Grenzen, p. 218: "...unmittelbar geschaut, erlebt, empfunden werden können."

69.Heisenberg, Physics and Beyond, p. 29; Heisenberg, Der Teil und das Ganze, p. 48: "...du kannst auch sagen, ich habe die Theorie mit dem Kopf, aber noch nicht mit dem Herzen verstanden."

70.Heisenberg, Across the Frontiers, p. 137; Heisenberg, Schritte über Grenzen, p. 222.

71.Goethe, letter to C. D. von Buttel, May, 1827, cited in Across the Frontiers, p. 133; Heisenberg, Schritte über Grenzen, p. 218: "'Schauen, wissen, ahnen, glauben und wie die Fühlhörner alle heißen, mit denen der Mensch ins Universum tastet, müssen denn doch eigentlich zusammenwirken, wenn wir unseren wichtigen, obgleich schweren Beruf erfüllen wollen.'"

72.Heisenberg, Across the Frontiers, p. 137; Heisenberg, Schritte über Grenzen, p. 222: "'Episteme' ist eben dieses unmittelbare Gewißwerden, auf dem man ruhen kann, hinter dem man nichts weiter zu suchen braucht."

73.Enneads I, 6, 4, trans. by A. H. Armstrong.

74.Heisenberg, Across the Frontiers, p. 182; Heisenberg, Schritte über Grenzen, p. 269: "Die Schönheit ist das Durchleuchten des ewigen Glanzes des 'Einen' durch die materielle Erscheinung."

75.Heisenberg, Across the Frontiers, p. 174; Heisenberg, Schritte über Grenzen, p. 261: "Die Schönheit ist der Glanz der Wahrheit."

76.Ibid., p. 177; Heisenberg, Schritte über Grenzen, p. 264: "Aber daß es dieses ganz unmittelbare Erkennen gibt, dieses Erschrecken vor dem Schönen, wie es bei Plato im 'Phaidos' heißt, daran kann wohl nicht gezweifelt werden."

77.The Republic, Book 5, p. 276.

78.Heisenberg, Physics and Philosophy, p. 109.

79.Heisenberg, Physics and Beyond, p. 247; Heisenberg, Der Teil und das Ganze, p. 333: "Wer über die Philosophie Platos meditiert, weiß, daß die Welt durch Bilder bestimmt wird."

80.Heisenberg, Physics and Philosophy, p. 108.

81.Eckhart, Quasi vas auri solidum, translated by Matthew Fox, in Breakthrough (New York: Image Books, 1980).

82.Heisenberg, Physics and Philosophy, p. 108.

83.Ibid., p. 200.

84.Ibid., p. 170.

85.Ibid., p. 201.

86.Heisenberg, Across the Frontiers, p. 85; Heisenberg, Schritte über Grenzen, p. 166: "Wenn zunächst von vielen wichtigen Einzelheiten abgesehen wird zugunsten des einen Merkmals, an dem die Ordnung der Erscheinungen gelingt, so beschränkt man sich von selbst auf Herausarbeiten einer Grundstruktur, einer Art von Skelett, das erst durch das Hinzufügen einer großen Fülle weiterer Einzelheiten zu einem wirklichen Bild werden könnte."

87.Heisenberg, Physics and Philosophy, p. 170.

88.Cited in Physics and Philosophy, pp. 170-171.

89.Ibid., p. 171.

90.Heisenberg, Physics and Beyond, p. 88; Heisenberg, Der Teil und das Ganze, p. 123: "Wenn in den Religionen aller Zeiten in Bildern und Gleichnissen und Paradoxien gesprochen wird, so kann das kaum etwas anderes bedeuten, als daß es eben keine anderen Möglichkeiten gibt, die Wirklichkeit, die hier gemeint ist, zu ergreifen. Aber es heißt nicht, daß sie keine echte Wirklichkeit sei."

91.Heisenberg, Across the Frontiers, p. 121; Heisenberg, Schritte über Grenzen, p. 205: "...die im Hörer Bilder erzeugt, die ihm eine ganz andere Art des Verstehens vermittelt."

92.Heisenberg, The Physicist's Conception of Nature, p. 57; Heisenberg, Das Naturbild der heutigen Physik, p. 40: "Die Mathematik ist sozusagen die Sprache, in der die Frage gestellt und beantwortet werden kann, aber die Frage selbst zielt auf einen Vorgang in der praktischen materiellen Welt; die Geometrie zum Beispiel diente der Vermessung von Ackerland."

93.Heisenberg, Across the Frontiers, p. 176; Heisenberg, Schritte über Grenzen, p. 262: "Wenn im Mittelalter eine große Kathedrale gebaut werden sollte, so waren viele Baumeister und Handwerker beschäftigt. Sie waren erfüllt von der Vorstellung von Schönheit, die durch die ursprünglichen Formen gesetzt war, und sie waren durch ihre Aufgabe gezwungen, im Sinne dieser Formen genaue sorgfältige Arbeit zu leisten."

94.Ibid.; Heisenberg, Schritte über Grenzen, p. 263: "Vielleicht darf man allgemein sagen, daß durch zugrunde liegenden Strukturen...Richtlinien gezogen oder sogar Wertmaßstäbe gesetzt werden, an denen objectiv entschieden werden kann, ob eine gestellte Aufgabe gut oder schlecht gelöst worden ist. Gerade dadurch, daß hier präzise Forderungen gestellt werden, daß der Einzelne durch kleine Beiträge mitwirken kann an dem Erreichen großer Ziele, daß über den Wert seines Beitrags objektiv entschieden werden kann, entsteht die Befriedigung, die von einer solchen Entwicklung für den großen beteiligten Kreis von Menschen ausgeht."

95.Heisenberg, Physics and Beyond, p. 243; Heisenberg, Der Teil und das Ganze, p. 328.

96.Heisenberg, Across the Frontiers, p. 177; Heisenberg, Schritte über Grenzen, p. 263: "Der einzelne Techniker, der irgendein Teilgerät für das Flugzeug konstruiert, der Arbeiter, der es herstellt, weiß, daß es auf die äußerste Genauigkeit und Sorgfalt bei seiner Arbeit ankommt, daß vielleicht sogar das Leben vieler Menscher von seiner Zuverlässigkeit abhängt. Daher gewinnt er den Stolz, den eine gut geleistete Arbeit gewährt, und er freut sich mit uns an der Schönheit des Flugzeugs, wenn er empfindet, daß in ihm das technische Ziel mit den richtigen angemessenen Mitteln verwirklicht ist."

97.Ibid., p. 28; Heisenberg, Schritte über Grenzen, p. 41: "Man findet Strukturen, die so ineinander verknüpft und verschlungen sind, daß man eigentlich an keiner Stelle mehr Änderungen vornehmen kann, ohne alle Zusammenhänge in Frage zu stellen. Man wird hier etwa an die kunstvollen Bandornamente arabischer Moscheen erinnert, in denen so viele Symmetrien gleichzeitig verwirklicht sind, daß man nicht ein einziges Blatt verändern könnte, ohne den Zusammenhang des Ganzen entscheidend zu stören."

98.Heisenberg, Physics and Beyond, p. 199: Heisenberg, Der Teil und das Ganze, p. 272: "[bedenken Sie] diese allgemeinen Zusammenhänge..."

99.Heisenberg, The Physicist's Conception of Nature, p. 19; Heisenberg, Das Naturbild der heutigen Physik, p. 14: "So wie sich in der Naturwissenschaft jede Einzelfrage der großen Aufgabe unterordnet, die Natur im Ganzen zu verstehen, so dient auch jeder kleinste technische Fortschritt dem allgemeinen Ziel, die materielle Macht des Menschen zu erweitern. Der Wert dieses Zieles wird ebensowenig in Frage gestellt wie in der Naturwissenschaft der Wert der Naturerkenntnis, und beide Ziele fließen in eines zusammen in dem banalen Schlagwort "Wissen ist Macht.'"

100.Heisenberg, Across the Frontiers, p. 210; Heisenberg, Schritte über Grenzen, p. 297: "Der Arzt kann den Kranken nur dann von Leiden befreien, wenn er die biologischen Gesetze kennt und ausnützt, die das Geschehen im Organismus regeln."

101.See The Physicist's Conception of Nature/Das Naturbild der heutigen Physik.

102.Heisenberg, Across the Frontiers, pp. 130-131; Heisenberg, Schritte über Grenzen, p. 215: "Die von Newtonschen Naturwissenschaft bestimmte Welt, von der Goethe hoffte, daß er ihr ausweichen könnte, ist also unsere Wirklichkeit geworden, und es hilft uns gar nichts, daran zu denken, daß in ihr auch Fausts Partner seine Hand im Spiele hat. Man muß es hinnehmen, so wie man es zu allen Zeiten hingenommen hat."

103.Goethe, Wilhelm Meisters Wanderjahre (III, 13; Artemis Ed., VIII, p. 460), cited in Across the Frontiers, p. 130; Wanderjahre, cited in Schritte über Grenzen, p. 215: "'Das überhandnehmende Maschinenwesen quält und ängstigt mich. Es wälzt sich heran wie ein Gewitter, langsam, langsam. Aber es hat seine Richtung genommen, es wird kommen und treffen.'"

104.Cited in The Physicist's Conception of Nature, p. 21, Das Naturbild der heutigen Physik, p. 16: "...Wenn einer Maschinen benutzt, so betreibt er alle seine Geschäfte maschinenmäßig; wer seine Geschäfte maschinenmäßig betreibt, der bekommt ein Maschinenherz. Wenn einer aber ein Maschinenherz in der Brust hat, dem geht die reine Einfalt verloren. Bei wem die reine Einfalt hin ist, der wird ungewiß in den Regungen seines Geistes. Ungewißheit in den Regungen des Geistes ist etwas, das sich mit dem wahren Sinn nicht verträgt. Nicht daß ich solche Dinge nicht kennte, ich schäme mich, sie anzuwenden."

105.Heisenberg, Across the Frontiers, p. 131; Heisenberg, Schritte über Grenzen, p. 216.

106.Ibid.; Heisenberg, Schritte über Grenzen, p. 216: "...daß Zweckmäßigkeit überhaupt kein Wert ist, sondern die Wertfrage nur um eine Stelle verschiebt; nämlich zu der anderen Frage: Ist der Zweck wertvoll, dem die betreffenden Erkenntnisse und Möglichkeiten gemaß sind, dem sie dienen sollen?"

107.Ibid., p. 130; Heisenberg, Schritte über Grenzen, p. 215: "Reichtum und Schnelligkeit ist, was die Welt bewundert und wonach jeder strebt."

108.Ibid.; Heisenberg, Schritte über Grenzen, p. 216: "...in entsetzlichen Katastrophen..."

109.Ibid.; Heisenberg, Schritte über Grenzen, p. 216: "Das entscheidet sich erst mit den Wertvorstellungen, von denen sich die Menschen beim Setzen der Ziele leiten lassen. Diese Wertvorstellungen können nicht aus der Wissenschaft selbst; jedenfalls kommen sie einstweilen nicht daher."

110.Heisenberg, The Physicist's Conception of Nature, p. 31; Heisenberg, Das Naturbild der heutigen Physik, p. 22: "Mit der scheinbar unbegrenzten Ausbreitung ihrer materiellen Macht kommt die Menschheit in die Lage eines Kapitäns, dessen Schiff so stark aus Stahl und Eisen gebaut ist, daß die Magnetnadel seines Kompasses nur noch auf die Eisenmasse des Schiffes zeigt, nicht mehr nach Norden. Mit einem solchen Schiff kann man kein Ziel mehr erreichen; es wird nur noch im Kreis fahren und daneben dem Wind und der Strömung ausgeliefert sein. Aber um wieder an die Situation in der modernen Physik zu erinnern: Die Gefahr besteht eigentlich nur, solange der Kapitän nicht weiß, daß sein Kompaß nicht mehr auf die magnetischen Kräfte der Erde reagiert. In dem Augenblick, in dem Klarheit geschaffen ist, kann die Gefahr schon halb als beseitigt gelten. Denn der Kapitän, der nicht im Kreise fahren, sondern ein bekanntes oder unbekanntes Ziel erreichen will, wird Mittel und Wege finden, die Richtung seines Schiffes zu bestimmen. Er mag neue, moderne Kompaßarten in Gebrauch nehmen, die nicht auf die Eisenmasse des Schiffes reagieren, oder er mag sich, wie in alten Zeiten, an den Sternen orientieren. Freilich können wir nicht darüber verfügen, ob die Sterne sichtbar sind oder nicht, und in unserer Zeit sind sie vielleicht nur selten zu sehen. Aber jedenfalls schließt schon das Bewußtsein, daß die Hoffnung des Fortschrittglaubens eine Grenze findet, den Wunsch ein, nicht im Kreise zu fahren, sondern ein Ziel zu erreichen. In dem Maße, in dem Klarheit über diese Grenze erreicht wird, kann sie selbst als der erste Halt gelten, an dem wir uns neu orientieren können."

111.Heisenberg, Across the Frontiers, p. 118; Heisenberg, Schritte über Grenzen, p. 203: "Der große Erfolg der wissenschaftlichen Methode, mit Versuch und Irrtum, schließt in unserer Zeit jede Definition der Wahrheit aus, die den scharfen Kriterien dieser Methode nicht standhielte."

112.Heisenberg, **The Physicist's Conception of Nature**, pp. 21-22; Heisenberg, Das Naturbild der heutigen Physik, p. 16: "...die Einfalt der Seele, von der der Philosoph spricht, ist nie ganz verlorengegangen, sondern im Laufe der Jahrhunderte bald schwächer, bald stärker in Erscheinung getreten und immer wieder fruchtbar geworden."

113.Heisenberg, Physics and Beyond, p. 84; Heisenberg, Der Teil und das Ganze, p. 119: "Die Entfaltung der Naturwissenschaft in den letzten zwei Jahrhunderten hat doch sicher das Denken der Menschen im ganzen verändert, auch über den christlichen Kulturkreis hinaus. So unwichtig ist es also nicht, was die Physiker denken. Und es war gerade die Enge dieses Ideals einer objektiven im Raum und Zeit nach dem Kausalgesetz ablaufenden Welt, die den Konflikt mit den geistigen Formen der verschiedenen Religionen heraufbeschworen hat. Wenn die Naturwissenschaft selbst diesen engen Rahmen sprengt - und sie hat das in der Relativitätstheorie getan, und dürfte es in der Quantentheorie, über die wir jetzt so heftig diskutieren, noch viel mehr tun - so sieht das Verhältnis zwischen der Naturwissenschaft und dem Inhalt, den Religionen in ihren geistigen Formen zu ergreifen suchen, doch wieder anders aus. Vielleicht haben wir durch die Zusammenhänge, die wir in den letzten dreißig Jahren in der Naturwissenschaft dazugelernt haben, eine größere Weite des Denkens gewonnen."

114.Heisenberg, The Physicist's Conception of Nature, p. 31; Heisenberg, Das Naturbild der heutigen Physik, p. 23: "Der Raum, in dem der Mensch als geistiges Wesen sich entwickelt, hat mehr Dimensionen als nur die eine, in der er sich in den letzten Jahrhunderten ausgebreitet hat."

115.Heisenberg, Across the Frontiers, p. 121; Heisenberg, Schritte über Grenzen, p. 206: "...die Sprache der Bilder und Gleichnisse ist wahrscheinlich die einzige Art, sich dem 'Einen' von allgemeineren Bereichen her zu nähern. Wenn die Harmonie in einer Gesellschaft auf der gemeinsamen Interpretation des 'Einen' beruht, des einheitlichen Prinzips hinter Erscheinungen, so dürfte an dieser Stelle die Sprache der Dichter wichtiger sein als die der Wissenschaft."

116.Ibid., p. 136; Heisenberg, Schritte über Grenzen, p. 221: "[Die Auflösung der Kunst ist...] die Folge des Verlustes jener Mitte, um deren Erhaltung Goethe sein ganzes Leben hindurch gerungen hat."

117.Ibid., p. 87; Heisenberg, Schritte über Grenzen, p. 169: "Die Auflösung alter Ordnungen, z.B. religiöser Bindungen in unserer Zeit spiegele sich in der Kunst in der Auflösung traditioneller Formen, von denen dann nur einzelne abstrakte Elemente übrigblieben."

118.Ibid., p. 87; Heisenberg, Schritte über Grenzen, p. 169: "...die Einsicht in sehr weite Zusammenhänge..."

119.Ibid., p 150; Heisenberg, Schritte über Grenzen, p. 236: "Wichtige Teile der modernen Kunst wären aber eher eine verwaschene, unbestimmte Kunst zu nennen oder, wie sie sich selbst manchmal bezeichnet, eine Kunst der Verneinung, der Auflösung..."

120.Ibid., p. 151; Heisenberg, Schritte über Grenzen, p. 236: "'Wir haben zwar mit unserem Lebensentwurf die Kulturen der Welt zerstört, aber das Tote lebt im Gewebe des Lebendigen weiter und wirkt.'"

121.Ibid.; Heisenberg, Schritte über Grenzen, pp. 236-37: "...so scheinen mir das zu große Worte für eine schlechte Sache; dieselbe Sache war ja auch in der Wissenschaft schlecht. Es bedarf größter Anstrengung, um von hier den Weg ins Geordnete zurückzufinden."

122.Heisenberg, Physics and Beyond, p. 193; Heisenberg, Der Teil und das Ganze, p. 263: "...daß die Fortschritte der Atomphysik, die ich 25 Jahre lang miterlebt hatte, nun den Tod von weit über hunderttausend Menschen verursacht hatten."

123.Ibid., p. 217; Heisenberg, Der Teil und das Ganze, p. 217: "Wenn einmal die magnetische Kraft ganz erloschen ist, die diesen Kompaß gelenkt hat - und die Kraft kann doch nur von der zentralen Ordnung her kommen -,so fürchte ich, daß sehr schreckliche Dinge passieren können, die über die Konzentrationslager und die Atombomben noch hinausgehen."

124.Heisenberg, Across the Frontiers, pp. 211-212; Heisenberg, Schritte über Grenzen, p. 298: "Wahrscheinlich spricht sich in diesen irrationalen Vorgängen unbewußt die Sehnsucht nach jenem Bereich aus, in dem Geist mehr ist als Information, Liebe mehr ist als Sexualität und Wissenschaft mehr ist als Sammeln von empirischen Daten und ihre Analyse."

125.Elisabeth Heisenberg, Inner Exile: Recollections of a Life with Werner Heisenberg, trans. by Cappellari and Morris (Boston: Birkhauser, 1980), p. 26. In Physics and Beyond, Heisenberg characteristically plays down his part in these activities, calling his participatory efforts "amateurish in the extreme" (p. 54).

126.Ibid.

127.Ibid.

128.Thomas Traherne, Centuries of Meditations: The First Century, 31, in Seventeenth Century Poetry and Prose, ed. by A.M. Witherspoon and Frank Warnke (San Diego: Harcourt Brace Jovanovich, 1982).

129.Ennead I, 6, 4, translation by Armstrong.

CHAPTER THREE: SCIENCE

> The search for the "one", for the ultimate source of all understanding, has doubtless played a similar role in the origin of both religion and science.[1]

As discussed in the first section, Heisenberg chose to make his contribution in science for the reason that science, at the time, seemed to be on the track of far more important structures than art. Although the physicist occasionally notes that the tasks of art and of science differ, ("Whereas science explains and makes intelligible, art has to present, to illuminate, to make visible the basis of human life"[2]), this does not strictly seem to be the case. An attempt will be made to demonstrate that although the structures that science hopes to make intelligible are of a different order than the structures of art, and thus, as noted above, needing a different language, the scientist has the same task as the artist, that is, the illumination of those basic structures. The structures discovered by science are as true and as much a part of the central order as those discovered by art. Still, mathematical science possesses no meaning by itself; only when its limits are understood, and it is subsequently given an appropriate place among the other avenues, does science become a deeply meaningful enterprise, and the structures uncovered this century take on the importance that Heisenberg was convinced they would have.

Thus, the first part of this chapter will attempt to illustrate Heisenberg's understanding of the study of nature,

from the ancient period to the foundations of the modern, where science is considered guided by and to the central order. This is a significant investigation, since it is in this perception of science that Heisenberg sees the true value of science. The insights of modern science, even when it has lost some of the depth that science possesses, are crucial to both the true understanding of science and true scientific understanding; in a way, the early moderns have streamlined science to a point of greater, if more modest, understanding. Of course, it is impossible to ignore the immodesty of later modern science, which will be discussed in a different context than it was above, since it directly bears on twentieth-century science.

The second part will demonstrate Heisenberg's continuation of that study initiated by the Pythagoreans. Effort will be made to show that scientific understanding is achieved in the same way as it is in art, i.e. the unfolding of structures through the unfolding of concepts, and the corresponding re-cognition of the structures in the scientist himself. Again, these structures that shine forth are structures of rational order, rather than value, but are structures nonetheless. Finally, the discussion will take on Heisenberg's understanding of the structure whose recognition seems to be on the horizon, a structure of utter importance, since it is the basic structure of all matter. That matter is,

at base, an Idea of that central order renews Heisenberg's faith in that central order.

PART I

That there existed many resolutions to the ancient question of principle besides the Pythagorean/Platonic one, the classically educated physicist of course has no doubt; he gives a large amount of credit to those early Greeks, who, confronted with the problem of the "one" and the "many", attempted to reduce everything to a fundamental material substance. It was, Heisenberg admits, characteristic of the time that the first philosophers look for a material cause of all things, and certainly he has no problem with this: "That seems to be a very natural starting point for a world which certainly consists of matter."[3] As a physicist, it is not surprising that he cannot condemn this material approach. Yet, he is well aware that conceptions of matter differed, and often those substances were not always wholly materialistic, as the modern world would understand it. For example, although Thales states that the material cause of all things is water, Heisenberg also notes that "life was connected with or inherent in this 'substance'", since Thales also says that all things are full of gods.[4] Considering the "one" and the "many", Heraclitus understands the fundamental unifying principle as change, or Becoming, and thus sees fire, as matter and a moving force, as the primary substance. Again, matter is characterized by vitality. But for time, many more examples could be cited, as Heisenberg is quite familiar with all the ancient material attempts to resolve the problem of

the one and the many, for each one, in its particular way, bears upon his own science; as he says of his youthful scientific studies, "I was gaining the conviction that one could hardly make progress in modern atomic physics without a knowledge of Greek natural philosophy."[5] Certainly, the concepts of antiquity have proven fertile even in our own time.

In particular, one such ancient concept that found fruitful application in the last century was that of atomism. Heisenberg notes that, following the above materialistic trend in Greek thought, the atomic solution to the problem of principle was offered by Leucippus and Democritus: they proposed as the fundamental substance the a-tomoi, indivisible smallest units of matter which had properties of Being, in that they were eternal, indestructible, and the primary substance. The physicist repeatedly takes the opportunity to discuss this solution, since, although atomism had proven itself a fruitful concept in the last century, twentieth century physics needed to challenge that atomistic thinking resurrected by nineteenth-century chemistry. That it needs to be challenged he has no doubt: although one may cite this century's discovery that atoms in fact consist of a number of particles, one must remember that a-tomicity is a concept that may still be applied to the smallest, or most basic, of these particles. Furthermore, the materialism of modernity is not

the same as the materialism of the ancient atomists: although for Democritus, "atoms were merely the letters with which we could record the events of the world, but not their content,"[6] the materialism of the nineteenth century is rooted in the Cartesian division of the world into separate material and spiritual realities. We will return to this modern materialism presently; for now, it is enough to say that, for Heisenberg, ancient atomicity, without laws by which the movements of atoms can be understood, is unable to explain why the atoms move as they do, thus not solving the problem of ultimate principle.

Of course, Heisenberg finds the greatest resolution of the question of the "one" and the "many" begun by the Pythagoreans. Above, we have mentioned the significance of mathematical relations to the Pythagoreans, who realized the beauty of music came not through the notes themselves, but in the mathematical ordering principle; here, the experience of understanding, the reduction of the many to one principle, becomes the experience of the beautiful. The same principle, the harmonious proportion of number, was turned to the universe, with its acknowledged beauty; the philosopher Cornford sums up this movement:

> If this thought is to be pursued in the physical direction, it leads to the Pythagorean doctrine that the reality of things lies, not in the unordered and indefinite principle of matter (the Unlimited), but in the opposite limiting principle of form and measure, proportion and number. All things we see and touch represent or embody number. Under this aspect of measurable quantity, the world of Nature can be known and

> understood. In astronomy, the speeds and distances of the heavenly bodies are ruled by the proportions of a harmony that was to be known later as the harmony of the spheres. The forms or surfaces which limit tangible bodies represent the perfect figures of geometry; and the laws of these figures can be finally reduced to relations of numbers. This discovery - that the key to physical science lies in mathematics - is one of those intuitions of genius which date from the childhood of philosophic speculation and still serve as guiding principles to science.[7]

As we shall see, for Heisenberg, the Pythagorean realization that the key to physical science lies in mathematics must be accompanied by their additional realization that scientific understanding is an experience of the beautiful, the beautiful not only as the proper conformity of the parts to each other and to the whole, but the beauty of the eternal splendor of the One as it shines forth; for the Pythagoreans, these harmonies are part of the divine and eternal fire irradiating the universe, of which we possess a spark. To know them was part of the soul's ascension, and thus geometry was only for the initiated.

In the previous section, Plato's adoption of these Pythagorean notions was discussed, as corresponding to the Forms or Ideals of Socratic aspiration. Further, as Heisenberg's friend and student, C.F. von Weizsäcker (noted both as a physicist and classical philosopher), points out, the higher understanding that is necessary to a class of ruling guardians must be prepared for by means of mathematics and mathematical science:

> To rule politically, one must have learned astronomy. Naturally this was as flabbergasting to Plato's readers

> as it is to us. Why should this be the case? It can only be so because the basic structures of reality manifest themselves in astronomy and physics (elementary particle physics, as we might say), and it is towards these that he who would be capable of grasping the more intricate structures of reality manifest in political life must turn his eyes.[8]

Of course, the realization that the movements of the planets can be understood as images of the geometrical principles in our mind is as yet insufficient to higher discovery; more than a mere working knowledge of geometry is deemed necessary by Plato. Most students of geometry work thus: taking for granted the assumptions or postulates that need no explanation or accounting for as being clear to everyone, they use the objects of the world as images of these geometrical understandings; in effect, this understanding is an end, a conclusion, rather than a move to a beginning, to a first principle. The true value of geometrical and mathematical knowledge arises only when these are not taken for granted, that is, only when, through the power of dialectic, these assumptions are treated, perhaps not exactly as beginnings, but hypotheses,

> that is to say steps and springboards for assault, from which it may push its way up to the region free of assumptions and reach the beginning of all, and grasp it, clinging again and again to whatever clings to this; and so may come down to a conclusion without using the help of anything at all that belongs to the senses, but only the ideals themselves, and, passing through ideals, it may end in ideals.[9]

It is in this sense, it would seem, that anyone who enters the Academy be 'geometrized'; only with the mind's absolute realization of these basic structures, achieved through the

power of pure reason (as opposed to the postulations of, so to speak, unenlightened geometricians), is there any possibility of a true release from the chains and ascension into the world of sunlight: "all this diligent study of the arts - those which we have been discussing [i.e. calculation, geometry, geometry of solid bodies, and astronomy]- has this power, a stirring and bringing out of the best in the soul to survey the best in things which really are, just as there it brought the clearest thing in the body to survey the most brilliant things in the bodily world of vision."[10] The Numbers are common to everything, and if genuine attention is given to them, they forcibly compel the soul upward into higher regions.

Given Plato's certainty that all observable nature is merely an image, generated through the eternal mathematical ideas, it is not surprising that his foray into the smallest units of matter would have as its basis geometry. In this, that is, the concept of the smallest units of matter, he was very much influenced by the notions of his time: "Democritus [whose books, Heisenberg notes, Plato had wished burnt] and Plato both had hoped that in the smallest units of matter they would be approaching the 'one', the unitary principle that governs the course of the world."[11] Of course, where Democritus' atoms can in a way be thought of as tiny billiard balls, Plato conceived those smallest units to be geometrical in form, the perfect solids, of which the basic substances of

the world were images. This idea will be presented in somewhat more depth later, as we observe Heisenberg utilizing the notion of mathematical harmony and symmetry in the understanding of elementary particles; what is important to remember is that this Platonic science is guided by, through beauty, and to, in beauty, the central order, where beauty is both that conformity and the translucence.

Although Aristotle was very much concerned with the problem of the "one" and the "many" (continuing with the Platonic idea of Forms, though these were transmitted almost genetically), Heisenberg notes that he was most uncomfortable with the mathematical reductions of the Pythagoreans. He quotes The Philosopher: "[the Pythagoreans] are not seeking for theories and causes to account for observed facts, but rather forcing their observations and trying to accommodate them to certain theories and opinions of their own."[12] An empiricist himself, Aristotle is famous for his careful investigation of observable nature, and his Physics, "in spite of its general nonmathematical character and in a sense qualitative character, was enormously influential in the subsequent development of physical ideas during the medieval period."[13] Although, obviously, Aristotle himself did not leave his work without theory, so powerful was his thought, that for centuries science consisted of mere description of details, without any viewpoint from which order might have been discernible, particularly a mathematical one, "and thus

the road to knowledge diverged for a long time from the road to the beautiful."[14] This changed for the better, in Heisenberg's view, during the Renaissance, with the revival of mathematical Platonic thought in conjunction with - or rather, in the "tension" between - Aristotelian empirical thought.[15] Below is a study of those early moderns, in whom Heisenberg sees the true foundations of modern science, foundations which profoundly affected his own work and thought.

It often appears that the most important foundation, to Heisenberg, is the one laid by Kepler, in whom Heisenberg sees a kindred soul to Plato. There are two aspects of Johannes Kepler's work and thought that Heisenberg believes will strike those who have definite ideas concerning contemporary science. The first is Kepler's Platonic understanding of science as not at all a means to technological progress, but quite the contrary, "science [as] a means of elevating the mind, a way of finding peace and solace in the contemplation of the eternal perfection of the Creation."[16] At the end of the Middle Ages, nature was still very much seen as primarily created by God; in fact, Kepler states that "nothing is more precious, nothing more beautiful than our magnificent temple of God."[17] He speaks explicitly of the Book of Nature, and the heavens, he proclaims with David, declare the glory of God. In the following passage, Kepler deliberately calls up images evocative of the religious life, equating that scientific contemplation with the spiritual:

> Yes, there will once again come a Charles, who as ruler of Europe will seek in vain that which he, tired of ruling, finds in the narrow cell of his monastery; who among all the festivities, titles, triumphs, riches, cities, and kingdoms, finds so great a joy in the planetary sphere constructed after Pythagoras and Copernicus, that he renounces the whole world for it and prefers ruling the heavenly orbits with his measuring instruments to governing people with his sceptre...[18]

Enlightening is his qualification that this joy of astronomy only comes to the soul which is seeking its ascent: "astronomy is not food for everybody, without distinction, but only for the aspiring soul."[19] The soul comes to astronomy only after it has failed to discover inspiration or lasting value in the works of humanity, anything to still its hunger and satisfy it: "then will he hasten to seek out better things, then will he immerse his spirit, troubled by empty worries, into that great tranquillity..."[20] That tranquillity, of course, is the contemplation of the harmony of the world, particularly of the heavens, generated through the pure and eternal archetypes, derived from God's own essence: "We can but exclaim with Plato that <u>God is a great geometrician</u>."[21] Although it had never been fully lost, this is an important re-cognition and revival of the Platonic understanding and method of the study of nature. Able to recognize the geometrical harmony because humans are created in God's image, those structures within us now shine forth 'truly and vividly', where before they were only obscurely visible. Heisenberg cites Kepler's joyous concluding words of his work on the harmony of the universe: "I thank thee, Lord

God our Creator, that thou allowest me to see the beauty in thy work of creation."[22]

This leads to the other aspect of Kepler's work that Heisenberg believes will appear strange to the contemporary reader, that is, Kepler's "remarkable disdain of empirical facts."[23] Experience in Kepler's thought is only that accidental discovery of relations, "that can be understood much better from an insight into a priori reasons;"[24] that is, the relations accidentally discovered in empirical fact around us are better understood through those archetypes that exist even before they shine more vividly within through the recognition of correspondence without. Those forms within are in a sense more true than those without.

> The complete correspondence between 'things of the senses' -i.e., the works of God - and mathematical and intelligible laws - the 'thoughts' of God - becomes the fundamental concept of the 'Harmonices Mundi'. Platonic and neo-platonic considerations lead Kepler to the conviction that the reading the works of God - in nature - is nothing but the understanding of the relationship between quantities and geometric forms. 'Geometry, eternal like God, and shining forth from the divine Spirit, supplied God with the pictures for completing the world, so that it might be the best, the most beautiful, and the world that most closely resembled the Creator.'(Harmonices mundi)[25]

Those two aspects, which characterize Kepler's science as Platonic, fade, says Heisenberg, as we are plunged more directly into modern science by Galileo, particularly in his notion that our conclusions about nature must follow empirical observation. Although, like Kepler, Galileo saw the universe as the Book of Nature, he did not hold the same ideas

concerning our abilities to read it. Heisenberg paraphrases Galileo, "Nature does not create first the human spirit, and afterwards things so that these might suit it, but rather the opposite is the case."[26] The episteme of which Kepler speaks is granted by Galileo only to God: "Now, these inferences which our minds learn but slowly and gradually, are penetrated by the Divine Wisdom like light, in an instant."[27] If Heisenberg understands Galileo correctly, that scientist held that our only understanding of the laws of nature was a step by step one, and the scientific method becomes one almost of trial and error: certain assumptions are put forward, tested, and then rejected or acclaimed as a natural law on the basis of empirical validity. For Galileo, that the mind can evolve assumptions for the observation of nature which are mathematically and logically valid is no proof of the existence in nature of those relations implied by the assumption; "only when the latter are used as empirical hypotheses and are proven by experiment do they assume the character of natural laws."[28] The validity of those unproven assumptions remains, but not as a natural law.[29]

Yet, it cannot be emphasized enough, states Heisenberg, that for a Galileo following the teachings of Pythagoras and Plato, those laws were to be mathematically beautiful ones. Thus, "and this is a crucial point, he is obliged, in order to recognize the beauty of mathematical forms in the phenomena, to idealize the facts, or, as Aristotle disparagingly put it,

to force them."[30] Whereas Aristotle held that all moving bodies eventually come to rest, a fact of general experience, Galileo holds that in the absence of external forces acting upon a body, that body in motion will continue in a state of motion; Galileo is able to do this by pointing out that although all moving bodies are exposed to frictional resistance, motion continues longer the more effectively these frictional forces can be cut off. Heisenberg observes: "In exchange for this forcing of the facts, this idealization, he obtained a simple mathematical law, and this was the beginning of modern exact science."[31] This is a critical realization, that science does deal in idealizations, rather than natural 'facts', something that the modern world would forget, to its own peril.

In reality, then, it would appear that Galileo is much closer to Kepler's empirical disdain than that scientist would probably have admitted to. Ostensibly, though, the situation took an empirical turn: given that we must check our assumptions with experience and observation, our senses become of primary importance; thus, what Heisenberg finds new about these ideas is the concern not with the observation of nature alone, but with "<u>observation guided by certain principles and definite rules of thought</u>." He continues: "This is nothing else but the experimental observation for determining whether and to what extent certain theoretical concepts agree with observation."[32] Hence, the study of nature can admittedly

only occur in particular sectors, those which are exposed to the tools of our observation and experimentation, our senses. In this manner, then, Heisenberg notes that although science was for Kepler an unhistorical enterprise, where the phenomena are attributed with an eternal, metaphysical and theological character, independent of observation, it definitely becomes a historical one for Galileo, "because the properties of the phenomena to be determined are only investigated from the viewpoint of man-made hypotheses."[33] A change in theory must be accompanied by a corresponding change in the description of the phenomena. In the particular limits set by the scientist, nature will of course always give the same answer, "but it is just this 'eternal', immutable behaviour according to law that has now become the object of scientific striving, and its realization the pride of the scientist,"[34] rather than service to the divine. This last aspect of Galileo's work is not one for which Heisenberg feels any affinity.

The mathematical and logical assumptions to which Galileo gives validity, though he will not give them status as a natural law, have no place in Newton's thought. For that scientist, there is only one way to determine natural law, and that is from the phenomena itself, by a double process of analysis and synthesis. Roger Cotes, in his introduction to Newton's Mathematical Principles of Natural Philosophy, writes that although scientists like Newton are concerned with the question of principle, they "never recognize as a principle

what has never been made manifest [emphasis Heisenberg's]."[35] Thus, by means of analysis, the forces of nature and the laws governing them are gleaned from a few well-chosen phenomena; synthesis comes into play when those forces and laws are used to explain the properties of the remaining phenomena. Again, as with Galileo, uncertain assumptions must be subordinated to strict observation and experiment, experiment being those problems thought out to test the validity of the theory.

The 'fall of the soul', as it were, is once more demonstrated here, as it is thought either ridiculous or presumptuous that the human mind should be able to grasp these laws through its own accord; at this point, it seems a given already that our method of knowing can be characterized as 'plodding'.[36] Heisenberg sums up Cotes' convictions:

> Whoever believes that he can discover the principles of nature or the laws of things by relying on the powers of his mind alone, or on the inner light of his reason, must either assume that the world arose by necessity and that all laws follow from this necessity; or else he must believe that, although God created the order of nature, he, a mere mortal, can see what is best to do.[37]

Yet, although Newton would "frame no hypotheses," Heisenberg is undoubtably aware of those contemporary accusations that charged Newton did in fact utilize hypotheses: "These attacks were not directed to the generally unquestionable mathematical portion of the Principia and the development there of the principle of gravitation, but had rather to do with Newton's claim that his system required no hypotheses, and was thus to be preferred to the Cartesian

hypothesis of vortices."[38] Here, we do not mean hypothesis as 'springboard' into higher levels of reality, as the word was used in connection with Plato, but merely an assumption from which to approach the study of nature. The problem, it seems, lay in the perception of Newton holding the attraction of matter as an essential property of matter; this, the accusers charged, is a hidden quantity, that is, not available to sensory experience or experimental observation (Newton denies that he meant to assert gravity as an essential property of matter).

Although Heisenberg never charges Newton along the same lines, it is clear from his deep conviction that theory decides what we can observe, of which more will be heard presently, that he understands Newton as indeed framing hypotheses. For Heisenberg, any such science that reveals all that Newton's did must be a profound re-cognition. Kepler, he says, was tremendously and openly struck by his recognition of a connection of the highest beauty; "A few decades later, Isaac Newton in England had set forth this connection in all its completeness, and described it in detail in his great work Principia Mathematica."[39] That the definition of beauty, in its first sense of the proper conformity of the parts to each other and to the whole, can be applied to his work "scarcely needs explaining," although we will briefly illustrate it: Newton's famous inverse square law, through which he first understood gravity, is perhaps one of the easiest

illustrations of a mathematical form of great beauty; originally applied to the solar system, it has found many other applications in science, right down to quantum physics, when approached classically: if the separation between a proton and an electron is doubled, the electromagnetic force falls to 1/4 of its value; if trebled, the force is 1/9, etc. This is, of course, the same kind of harmony and beauty that struck the Pythagoreans, and guided the early modern scientists, like Kepler and Newton, along their path.

The important point is that Newton did, in fact, frame a hypothesis, or, make an assumption: the laws of nature, whereby different phenomena are gathered together and understood, must be understood through relatively simple mathematical principles. Of course, it is in this mathematically ordered relation of the many to the one that Heisenberg finds the roots of exact science, and he thus declares: "in exact science, no less than in the arts, [beauty] is the most important source of illumination and clarity."[40] For example, asks Heisenberg, who understood the planetary motion better: Ptolemy or Newton? He notes that although Aristarchus theorized that the sun was the centre of the planetary system, Ptolemy held the earth in that position, and treated the orbits of the planets as superimposed cycles and epicycles; yet, his correct predictions of solar and lunar eclipses guaranteed the validity of his theory for fifteen hundred years. Had Ptolemy, inquires Heisenberg, "really

understood the planetary system? Was it not Newton who, knowing the law of inertia, and introducing force as the cause of changes of momentum, was the first to give a proper explanation of planetary motions in terms of gravitation? Was he not the first to have really understood this type of motion?"[41] Scientific understanding means much more to Heisenberg than the ability to predict, and here we again observe that the experience of understanding is the experience of the beautiful.

Heisenberg even brings the higher definition of beauty to bear on Newton's work, that is, the recognition of truth by its splendor, the shining forth of its beauty. Heisenberg doubtless believes that Newton experienced this beauty, and it is true that Newton was so struck with his results that he wished the rest of nature could be derived from the same kind of reasoning from mechanical principles, and hoped that "the principles here laid down will afford some light to this or some truer method of philosophy."[42] Heisenberg certainly is convinced that the beauty still shines forth here for all to see, as he quite apparently sees it, and consequently, he holds a high opinion of Newton's work:

> Newton had created a celestial physics, without arbitrariness or miracles, self-consistent and self sufficient, without any sliding into the path of materialism. He held fast to a belief in a personal God, mechanics in nature being but a means to His ends. Even when the 'great ocean' of reality remains undiscovered, the individual facts are yet fused into a great whole by their relations. Hence Newton's famous declaration: 'I do not know what I may appear to the world; but to myself I seem to have been only like a boy playing on the sea-

> shore, and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me.'[43]

It is just this statement by Newton that characterizes for Heisenberg the conscious modesty of early modern science concerning the study of nature: "it made statements about strictly limited relations that <u>are only valid within the framework of these limitations</u>."[44] A whole ocean of truth still lay before these scientists, who, for the most part, would never claim that all of reality could be explained or understood through mathematical science (although Kepler would affirm that what could be known therefrom was profound indeed).

This modesty was short lived, and the mechanistic-materialist world view has been mentioned earlier. The following discussion bears more on its scientific implications, rather than its societal. At this time, "Physical knowledge was considered to make assertions about nature as a whole. Physics wished to turn philosopher, and the demand was voiced from many quarters that all true philosophy must be scientific."[45] In ever-wider realms of nature, attempts were made, from the phenomena itself, to isolate the details of natural processes, and thus determine their 'laws'. It is important to remember that early modern science was specifically concerned with laws of <u>motion</u>, with the mechanics of matter, rather than the nature of matter itself. Precisely, the focus was dynamics, the branch of mechanics dealing with

the motions of material bodies under the action of given forces, as recognized by Newton. Heisenberg, of course, is fully aware that modern science has these roots in the dynamic problem: "the constant element in physics since Newton is not a configuration or a geometrical form, but a dynamic law."[46] Thus, the extension of the ideas of early modern science is the extension of the laws of mechanics.

Descartes in particular is, for Heisenberg, guilty of this immodesty. He valued mathematics so highly, that he believed the road to the investigation of all truth began there, particularly in those mathematical laws of mechanics. Physics is not for him a study of matter, but of the motion of matter, the process of its formation interpreted merely as a causal chain of events.[47] From a psycho-physical dualism, i.e. res cogitans and res extensa, Descartes was the first to "attempt the development of the mechanics not only of the celestial vault, but also of the soul, of organic as well as inorganic nature; for him physiology was no less a mechanical science than was astronomy. Nature can be explained only by itself, and its laws are identical with those of mechanics."[48] Descartes goes so far as to use the results of scientific research to confirm the principles of philosophy, and Heisenberg points out that this urge to come to philosophical conclusions through scientific research soon became a very important one: "The modesty which granted validity to natural laws only within the framework of

particular problems, or within strictly limited domains is here renounced."[49]

Furthermore, those mathematical laws are considered as extractions from nature itself, and not as products of our own mind; the laws are thought to follow from observation and experimentation. In this connection, Heisenberg cites the words of Jean Lerond D'Alembert: "As all our direct knowledge comes in by the Senses, all our Ideas are consequently due to our Sensations,"[50] and only those that can be sensibly demonstrated - through measurement - carry any validity at all. "It is not to be expected that amusing, arbitrary Hypotheses can help us to understand Nature."[51] Yet, in this study of Nature, "prosecuted partly from [no doubt Baconian] necessity, and partly for Amusement,"[52] these mathematical ideas hold a high place indeed, since they provide the simplicity that is necessary in the reduction of the many to the one - which, at this point, seems an almost odd hold-over from more insightful times, and doubtless one that Heisenberg understands as the saving grace of this period. Since, in this view, our only true knowledge comes from measurement, the discovery of mathematical relations is almost the only object it is possible to arrive at, or even need to propose to ourselves.[53] What the modern world is left with is only one truth, that of the measurable, with all other aspects of existence are devalued to the nth degree; this has been

explained and demonstrated elsewhere in greater detail than is possible or necessary here.

In a way, the situation of the mechanistic-materialist world view is perhaps worse than Plato could possibly ever have imagined. These mathematical laws were originally presented as axioms, that is, given truths that need no further explanation. For Plato, taking them for granted is bad enough, for it makes them meaningless, an unsatisfactory end. Certainly, he might say, they are correct, but only when one uses them as a springboard to a higher realm do they shine with truth, the truth that shines from all the ideas which cling to the highest good. Now, no Platonic philosopher ever denied that all things have number, nor would they deny that 'extended' things are susceptible to measurement. In fact, this is what made the mathematical study of nature so important to Plato, that number is common to all things; it is something with which people come into contact constantly, and thus it is the first thing that would compel their minds to contemplate number, thus moving up into the higher realms of ideas, where the more intricate structures of reality could be found. Here, though, mathematics does not even have the status of something we just 'know', but something we only discover through nature, and the only real mode of our knowing. The greatness of the soul, its divine spark, has no place at all in this thought, and, consequently, neither does Truth.

Given this, Heisenberg has a great deal of sympathy for the utter distaste of Goethe for this science, as pointed out earlier; Goethe, whose mature life was spent in the century that Heisenberg feels was greatly responsible for the total replacement of other avenues of understanding with a mechanistic one, found the Newtonian approach to the study of nature not only problematic, but dangerous. For Goethe, the observation and investigation of Nature began with the immediate sensory impression, and that poet/scientist was loathe ever to lose this immediate connection with nature by flights into total abstraction, that is, the consideration of nature under one viewpoint, disregarding all its other properties. At this point, it should be clarified that for modern science, this abstraction has two aspects, the recognition of the simple in the multiplicity of phenomena, and the use of mathematics to represent the phenomena. Thus, although Goethe demands this immediate connection to nature, Heisenberg would never characterize him as a 'modern' empiricist, since by this immediate connection he means not the observation of and experimentation upon nature to derive its mathematical laws, but that experience through 'seeing, knowing, sensing, believing and whatever all the feelers may be called, whereby man gropes about in the universe'. This, laments Goethe, is completely lost in the new science:

> And it is, in fact, the greatest evil of the more modern physics, that experiments are, as it were, separated from man himself, and that Nature is recognized only in that which artificial instruments demonstrate - nay, they want

> to prove and limit her capability by these. It is precisely the same with calculation. There is much that is true, that will not admit of being computed, just as there is a great deal that cannot be brought to the test of definite experience.[54]

In the realm of the abstract, says Goethe, one is adrift, without guidance, and thus at the mercy of the Devil. It was not so much that Goethe doubted the correctness of the method - he did, albeit unwillingly, accept the Copernican system - but held, in Platonic fashion, that there was a world of difference between correctness and truth; the Newtonian method may have fashioned a clever key, but it was unable to open the highest door. Heisenberg remarks:

> Goethe's cardinal objection to the post-Newtonian methodology of science is...assuredly directed against the divorce, in this methodology, of the concepts of 'correctness' and 'truth.' For him, truth was inseparable from the value concept. The 'unum, bonum, verum,' the 'one, the good and the true,' was for him, as it was for the old philosophers, the only possible compass by which mankind could be guided in seeking its course through the centuries.[55]

Heisenberg is in full agreement. Although discovering an order to nature, to not know 'why' nature acted according to certain laws, much less to care, makes the order discovered through the 'how' a partial one, drifting perilously without the guidance of relation to an ultimate central order: "the dangers have become as fully as threatening as Goethe foresaw. We have in mind, for example, the soulless depersonalizing of labour, the absurdity of modern armaments, the flight into insanity that took the form of a political movement. The Devil is a powerful fellow."[56] Nonetheless, says Heisenberg, that

region of utter clarity, a region he obviously discerned through art, and Goethe experienced in the whole of nature, "has also become visible in modern science, at the point where it yields intimations of the mighty unity in the ordering of the world."[57] It has become visible through the very abstractions of which Goethe was so frightened, through empirical support, and, most interestingly, through science's realization of its limitations.

Part II

> Heisenberg alludes to the fact that the bare datum of experience, in the sense that we normally know and recognize it, does not make clear why there should be very simple basic laws - laws that we can describe with a couple of simple mathematical concepts in spite of the fact that they determine an immense profusion of particular experiences.[58]

The major stumbling block to the perception of science as an avenue to religious understanding seems for Heisenberg to begin with the assumption that modern science rests on a purely empirical base. As has been noted, by the nineteenth century it was commonly thought that the mathematical relations which expressed the natural laws were arrived at through observation and experimentation: the notion that their discovery was simply a re-cognition of those same structures in our own mind carried little weight at all. However, turning specifically to Heisenberg, it is very doubtful that the physicist ever actually considered the beauty of mathematics as simply that which had been empirically derived from nature. He writes of his first experience therewith:

> ...very occasionally, an object that has thus come into our field of view will suddenly begin to shine in its own light, first dimly and vaguely, then ever more brightly, until finally it will glow through our entire mind, spill over to other subjects and eventually become an important part of our own life. This happened in my case with the realization that mathematics fitted the things of our experience, a realization which, as I had learnt at school, had already been gained by the Greeks, by Pythagoras and by Euclid.[59]

Clearly, in view of all that we have discussed above, he means by this that these basic structures within were re-cognized by

through the existence of those without; in fact, he is careful to characterize his realization as a correspondence, a 'fitting', rather than something learned: "the thought that mathematics somehow corresponded to the structures of our experience struck me as remarkably strange and exciting."[60] Perhaps it would not be too speculative to say that mathematics had struck Heisenberg exactly as Plato had wished it would strike a student. Furthermore, the idea of the unfolding of basic structures, which we have discussed above, is quite clear to the young Heisenberg; beginning a private study of more advanced mathematics, he sees nothing more than a continuation of the ancient efforts of mathematicians and philosophers, particularly in the achievements of Newton and his successors: "never once did it occur to me to consider the science and technology of our times as belonging to a world basically different from that of the philosophy of Pythagoras or Euclid."[61]

In fact, it was mathematics, rather than science or apparatus, that captured his attention in school, and the great physicist only acquired a special liking for physics after a "fortuitous" encounter with the new physics: an artist's rendition of a carbon dioxide molecule, illustrated by two atoms of oxygen and one of carbon, each furnished with hooks and eyes so they could hang together; the text stated that the ancient Greeks had conceived atoms to be the smallest, indivisible building blocks of matter. To begin

with, Heisenberg logically thought that "if their structure was complicated enough for them to have hooks and eyes, then they could not possibly be the smallest indivisible building-stones of matter."[62] Furthermore, their shapes struck the young man as arbitrary structures, "whose shape could be altered at will to adapt them to different technical tasks... [Yet] atoms and their combination into molecules were supposed to be governed by strict natural laws. This, I felt, left no room for such human inventions as hooks and eyes."[63]

It was pointed out to Heisenberg by a friend that the artist probably had no real idea of what atoms should look like, but because modern science is based on experience, rather than philosophic speculation, he has decided to represent them from particular experiences, and "'simply drew hooks and eyes in order to drive home the point that there are forms which lend themselves to the union of two but never of three oxygens to one of carbon.'"[64] A more philosophically-minded friend disputed this, saying that pictures which claim to facilitate our understanding only obscure the real problem, which seems to be the ability of our mind to grasp something which eludes direct observation. Nurturing the seeds already within Heisenberg's mind, the friend continued, stating his conviction that ideas are quite obviously prior to experience - "'indeed they are the prerequisite of all experience.'"[65] Thus, we are able to grasp the notion of atoms because it is already within us. In this, the friend cautioned against

speaking of atoms as 'things', preferring the term 'structure' in its widest connotation.

It was during this scientifically-oriented discussion of ideas and structures, Heisenberg informs us, that he suddenly recalled his reading of Plato's Timaeus, where the smallest particles of matter are described as consisting somehow of the geometrical solids, themselves made up of right-angled triangles. Although the whole theory seemed to be wild speculation, and it saddened Heisenberg "to find a philosopher of Plato's critical acumen succumbing to such fancies," he nonetheless found the entire scheme a fascinating one:

> I was enthralled by the idea that the smallest particles of matter must reduce to some mathematical form. After all, any attempt to unravel the dense skein of natural phenomena is dependent upon the discovery of mathematical forms, but why Plato should have chosen the regular bodies of solid geometry, of all things, remained a complete mystery to me.[66]

Of course, an older Heisenberg would realize that the ancient Greeks did not have the necessary observational and experimental data with which to arrive at statements of great accuracy;[67] yet, all the same, he notes that "some statements of ancient philosophy are rather near to those of modern science. This simply shows how far one can get by combining the ordinary experience of nature that we have without doing experiments with the untiring effort to get some logical order into this experience to understand it from general principles."[68]

No doubt this was a thought that Heisenberg grasped early on, for when reminded of the Timaeus, he realized that two ancient notions in Plato's work might well be applicable to the situation in atomic physics. First, Plato's discussion of the smallest units of matter in terms of geometry suggested to Heisenberg that the philosopher had understood them not as things, but as structures; therefore, modern science must not be seeking in atomic form a picture of the atom, but rather using the word 'form' in its widest sense: "They must be referring to the atom's structure in time and space, to the symmetrical properties of its forces, to its ability to form compounds with other atoms."[69] In a very interesting way, he perceives without the benefit of a deeper scientific education that the atomic form, or structure, is too rich to be captured in a picture, and remarks that "In all probability, such structures will forever elude our powers of graphic description, if only because they are not an obvious part of the objective world of things."[70] Connected to this impossibility of graphic description is the second ancient notion that Heisenberg considers potentially fruitful, that is, the openness of atomic structure to mathematical treatment. This idea is confirmed by Heisenberg's young friend, who agrees that "the new structures will elude all our attempts to construct tangible images," and further suggests that "they will prove to be abstract expressions of natural

laws rather than things."[71] Of course, in modern science, these natural laws had always been expressed in mathematics.

It was this possible mathematical connection, then, that seems to have initiated Heisenberg's interest in atomic physics, given that mathematics had already captivated his young mind. Countering, under Einstein's guidance, the Machian principle of thought economy, which holds that any theory is merely the conscious reduction of complicated sense impressions into a simple mathematical theory, Heisenberg insists with Einstein that mathematical, natural laws really exist:

> I believe, just like [Einstein], that the simplicity of natural laws has an objective character...it is not just the result of thought economy. If nature leads us to mathematical forms of great simplicity and beauty - by forms I am referring to coherent systems of hypotheses, axioms, etc.- to forms that no one has previously encountered, we cannot help thinking that they are 'true', that they reveal a genuine feature of nature.[72]

Heisenberg continues by noting that these forms may well cover our subjective relationship to nature - "they reflect elements of our own thought economy ['Denkökonomie'];"[73] however, when Heisenberg speaks of "thought economy" here, it would appear that he is simply discussing the abstract quality of the scientific study of nature, that is, the abstraction of one aspect of the universe, that susceptible to mathematical treatment, and the structures therein that correspond within and without. He adds, then, in Platonic fashion, that the laws of nature are not subjective impositions, but are genuine discoveries: "but the mere fact that we could never have

arrived at these forms by ourselves, that they were revealed to us by nature, suggests strongly that they must be a part of reality, not just of our thoughts about reality,"[74] meaning, clearly, that the structures must first be without for them to be re-cognized within.

Of course, recalling Heisenberg's consensus with Goethe concerning the distinction between 'correctness' and 'truth', there must necessarily exist for Heisenberg some criteria of truth, which would confirm without doubt that the form is indeed a part of reality. As mentioned just above, Heisenberg sees the mathematical forms of 'great simplicity and beauty' providing this criterion. In this, Heisenberg does not stray from modern scientific thinking, since even today it is still accepted by most scientists that beauty and simplicity are in fact hallmarks of good science, even by those scientists who often disregard the modern foundational reasons for the beauty of the laws of nature and their accessibility to humanity;[75] plainly, Heisenberg understands that those reasons and notions have fallen by the scientific wayside: "we are in our time very far from this theological foundation or justification of physics."[76] However, though this simplicity is for the most part now regarded as a measure of correctness, it is still understood by Heisenberg as a measure of truth:

> You may object that by speaking of simplicity and beauty I am introducing aesthetic criteria of truth, and I frankly admit that I am strongly attracted by the simplicity and beauty of mathematical schemes with which nature presents us...<u>the almost frightening simplicity and wholeness of the relationships which nature suddenly</u>

spreads out before us and for which none of us is prepared [emphasis added].[77]

Without a doubt, Newtonian mechanics embodies for Heisenberg that awesome simplicity and wholeness of relationship; its formal beauty begins with its possession of a very simple axiom system, capable of embracing a very wide set of relations.[78] However, it is crucial to realize that the simplicity and wholeness stems from the fact that Newtonian mechanics is what Heisenberg refers to as a "closed system". Heisenberg explains this by pointing out that Newton began his Principia with a deeply interconnected system of clearly delineated definitions and axioms; there, it is possible to represent each concept by a mathematical symbol, with the connections between the different concepts represented by mathematical equations expressed by means of symbols. "The mathematical image of the system ensures that contradictions cannot occur in the system."[79] Thus, the conceivable movements of matter under the influence of forces are represented by the possible solutions of the equations. This system, written in a set of mathematical equations, "is considered as describing an eternal structure of nature, depending neither on a particular space nor on a particular time."[80] Obviously, and this will be focused on more closely in a moment, it does in fact depend on a particular time and space, but where the phenomena concerned can be described by Newtonian concepts, his laws are valid to the highest degree:

> I think Newtonian mechanics cannot be improved in any way, for inasmuch as we can describe a particular phenomenon with the concepts of Newtonian physics - namely, position, velocity, acceleration, mass, force, etc. - Newton's laws hold quite rigorously, and nothing in this will be changed for the next hundred thousand years.[81]

True, even classical physicists knew that the accuracy with which the phenomenon can be described by these concepts had limits: it is humanly impossible to achieve a perfect degree of accuracy in measurement. Yet, "it is enough to assert that, inasmuch as it is possible to make accurate measurements of this kind at all, Newtonian mechanics is fully valid now and will remain so in the future."[82] To imagine that it can be improved is a grave misunderstanding; in its sphere of application, Newtonian mechanics has always proven itself abundantly sufficient: "There are no experiments to force [improvements] upon us. And this is why we can grant that Newtonian physics has an absolute validity; in its particular sphere of application it cannot be improved by small changes."[83] Of course, Newtonian physics as a "closed system" is better illustrated through a discussion of quantum physics, which contributed, though not exclusively, to a better understanding of it as such; a return to this will be made presently. Yet, in view of even these initial considerations, the simplicity and wholeness - the beauty - of Newton's laws should be better understood.

However, connected to the criteria of simplicity and beauty in the mathematical scheme is that of empirical

evidence. Although Heisenberg is strongly inclined to Platonic thought, he cannot dispense with the empirical requirements of modernity, not because he subscribes to a method of analysis and synthesis, but because of his conviction that fruitful discoveries are made through specific problems: truth is realized only through our interaction with the world. Thus, he states that "Pure mathematical speculation becomes unfruitful because from playing with the wealth of possible forms it no longer finds its way back to the smaller number of forms according to which nature is actually constructed."[84] Hence, although Heisenberg does not equate understanding with prediction, there is no doubt that prediction does in fact play a large role in determining the value of a theory; control by experiment is essential to the validity of any theory.[85] On the other hand, "pure empiricism becomes unfruitful because it eventually bogs down in endless tabulation without inner connection. Only from the tension, the interplay between the wealth of facts and the mathematical forms that may possibly be appropriate to them, can decisive advances spring."[86]

Finally, though the criteria of truth begin with the proper mathematical conformity of the parts to each other and to the whole, and the correspondence of that beauty to structures in nature, Heisenberg notes that the formal beauty and correspondence must partake of the 'splendor' of truth. Thus, when the physicist speaks of that 'almost frightening

simplicity and wholeness of the relationships which nature suddenly spreads out before us and for which none of us is prepared', he continues with an insight that stems more from a level of episteme rather than dianoia:

> And this feeling is something completely different from the joy we feel when we have done a set task particularly well [emphasis added].[87]

That is, the simplicity and beauty of the mathematical forms and the empirical correspondence are the preliminary requirements of the measure of truth; equally important is the immediate experience of it, a joyous certainty that something of immense consequence has been recognized, not invented:

> If, as we must always do as a first step in theoretical physics, we combine the results of experiments and formulae and arrive at a phenomenological description of the processes involved, we gain the impression that we have invented the formulae ourselves. If, however, we chance upon one of those very simple, wide relationships that must later be incorporated into the axiom system, then things look quite different. Then we are brought face to face with a relationship that has always existed, and that was quite obviously not invented by us or by anyone else. Such relationships are probably the real content of our science. Only when one has fully assimilated the fact of their existence can one really claim to have grasped physics [emphasis added].[88]

However, for one fully convinced of the truth of Newtonian physics, coming face to face with a new such relationship was perhaps a more frightening rather than joyful experience. Here, of course, we mean the great Max Planck, who, when deciding to go into physics at the beginning of the century, was told that almost all work in the field was complete. Thus, his concentration was on one of the remaining problems, that of "blackbody" radiation. Interesting to note

here is that, as in art, Heisenberg understands that it is possible to make new discoveries only when one is working as closely as possible with a theory already established as possessing truth. "It is precisely the wish to change things as little as possible which demonstrates that the introduction of novelty is a matter of being compelled by the facts; that the change of thought pattern is enforced by the phenomenon, by nature itself, and not by human authorities of any kind."[89] The scientifically conservative Planck illustrates this excellently, since his last wish was to upset the securely anchored edifice of classical physics. Yet, although energy was classically understood as moving continuously, Max Planck "finally discovered to his horror that in order to interpret blackbody radiation, he was obliged to frame a hypothesis which did not fit into the framework of classical physics and which, from the standpoint of this older physics, seemed completely insane"[90] - energy moved discretely, in packets - 'quanta'. Although Planck was decidedly upset over the necessity of his hypothesis, no way could be seen around it; nature itself had forced his hand. He did not like it, but he had experienced it: discussing his ideas with his son, "[Planck] explained that he felt he had possibly made a discovery of the first rank, comparable perhaps only to the discoveries of Newton."[91]

A revolution in scientific thought had begun. Einstein took this farther, explaining that light, or energy, was not

only absorbed and emitted in quanta, it was itself quantized. This was a blow to the classical understanding of light, which had already been proved to be a wave; however, Compton scattering experiments demonstrated that waves were in fact particles. De Broglie, in 1924, had already suggested that if waves behave as particles, then by analogy, particles could behave as waves. Of course, this is all connected to Niels Bohr's borrowing of quantum theory a few years earlier to explain the stability of the atom. He postulated that the electron existed in a discrete stationary state, the lowest of which is the normal state of the atom; therefore, after any kind of interaction, the electron would fall back into its normal state, and not spiral into the nucleus. This idea not only explained the stability of the atom, but other important phenomena, i.e. the emitted light spectra. Yet, though things were sufficiently explained, some contradictions remained, while new questions were opened up. For example, when and why does an electron jump to a new orbit and emit light? What is the direction of the emitted light? Why that direction? These classical questions presented difficulties for physicists. Of course, one may have, at one time, characterized electrons as the smallest units of tangible matter, like tiny billiard balls, and their motions comprehensible through Newtonian science. However, this "billiard ball" notion had suffered a jolt in Compton scattering and the implications of de Broglie's ideas. Later, then, acknowledging the possibility of

particles as waves, Bohr, along with Kramers and Slater, revised his picture: the waves of the electron particles were suggested to be 'probability waves'. The model was incorrect, but the idea came to be quite significant. However, nothing was yet truly understood.[92]

The point here is that once nature began presenting new aspects of itself, aspects that seemed to contradict the established, and revered, physics of modernity, the ground seemed pulled out from under the physicists, as Einstein once put it. Obviously, they were faced with new content, but they had no form with which to understand it. Heisenberg compares the state of early atomic theory to a mountain walk he once took with friends, and for those that are well acquainted with the real, human development of quantum mechanics, the comparison is an amusing, and heartwarming one (particularly the shouting in the fog):

> In the valley the weather was poor, and the mountains were veiled in clouds. During the climb, the mist had begun to close in upon us, and, after a time, we found ourselves in a confused jumble of rocks and undergrowth with no signs of a track. We decided to keep climbing, though we felt rather anxious about getting down again if anything went wrong. All at once the mist became so dense that we lost sight of one another completely, and could keep in touch only by shouting. At the same time it grew brighter overhead, and the light suddenly changed color. We were obviously under a patch of moving fog. Then, quite suddenly, we could see the edge of a steep rock face, straight ahead of us, bathed in bright sunlight. The next moment the fog had closed up again, but we had seen enough to take our bearings from the map. After a further ten minutes of hard climbing we were standing in the sun - at saddle height above the sea of fog. To the south we could see the peaks of the Sonnwend Mountains and beyond them the snowy tops of the Central Alps, and we all breathed a sigh of relief.[93]

This passage not only illustrates the human journey into quantum physics, but again characterizes Heisenberg's understanding of the nature of scientific truth, for he was the one to first glimpse the sunlit terrain before the fog closed up again; it may well be that his criteria of truth, discussed above, was prompted by his own work in atomic physics. First of all, Heisenberg's dislike of arbitrary pictorial images of atoms had inspired him to approach the atomic problem not in the manner of picture-construction, that is, asking what atoms were; rather, it should address what atoms did - their energy transitions. Here, basically, the atomic question consciously became that of quantum mechanics, in mathematical form. Second, straining to work out a mathematical scheme without contradictions, one which took into account all (and, he thought, nothing but) observable magnitudes, and one in which the principle of the conservation of energy would still apply, he is overcome by a strange experience, which he puts into words:

> ...it was almost three o'clock in the morning before the final result of my computations lay before me. The energy principle had held for all the terms, and I could no longer doubt the mathematical consistency and coherence of the kind of quantum mechanics to which my calculations pointed. At first I was deeply alarmed. I had the feeling that, through the surface of atomic phenomena, I was looking at a strangely beautiful interior, and felt almost giddy at the thought that I now had to probe this wealth of mathematical structures nature had so generously spread out before me.[94]

This immediate experience has been discussed in the previous section with regards to art, but it obviously applies equally

to science: "nature, I was certain, was made to be understood, or rather, our thought is made to understand nature...the same organizing forces that have shaped nature in all her forms are also responsible for the structure of our minds."[95] Although there was a great deal to be resolved in connection with quantum mechanics (specifically, the physical interpretation, i.e. how the atoms did what they did), it was the mathematical beauty, and his awed, 'alarming', realization that those beautiful structures were not invented, but re-cognized, that convinces Heisenberg of the theory's value. Note that Heisenberg, although the one doing the actual calculations, speaks of those mathematical scratchings as something with which nature had gifted him. It was nothing he himself had created, but something revealed to him.

However, owing to Heisenberg's modesty, and demonstrating his conviction that science is a dialogic enterprise, he characterizes quantum theory as a "shining forth of the great connection"[96] (as he considered the emergence of relativity theory) only after the physicists, taking their bearings from that moment of sunlight, found themselves standing heads above the sea of fog; that is, when a physical interpretation of the theory was discovered, a discovery which involved particularly Heisenberg and Bohr, but in which Heisenberg includes all the physicists who contributed to the Copenhagen Interpretation, both scientifically and through personal encouragement.

Of course, it is not surprising that Heisenberg refuses to take the entire credit for the development of the theory, although he does speak of that process within himself whereby the structures are "remembered in the soul."[97] But that "remembering" is not a process which Heisenberg restricts to himself, and he expresses it as one affecting most of the scientific community (Einstein is a notable exception), since the structures are in all souls. It was this recognition, generated by the new content, that "again restored exact science, under entirely new presuppositions, to that state of harmonious completeness which for a quarter of a century it had lost."[98] Yet, although Heisenberg may have been the first to come close to the final recognition which refurnished physics with that beautiful harmony, the basic structures are in every person, existing as the inner core, and in the direction physics was taking at the time, they would have been recognized by someone else, if not by Heisenberg: "We are bound up with the historical process, our lives are part of the process, and our choice seems to be restricted to the decision whether or not we want to participate in a development that takes place in our time, with or without our contribution."[99] As Einstein, he points out, would have had little chance to become a good scientist in the twelfth century, so it was inevitable that in the fruitful days of atomic physics, someone should come to the deep recognitions therein: "[in scientific research or in history] it seems

certain...that the individual is replaceable. If Einstein had not discovered relativity theory, it would have been sooner or later discovered by someone else..."[100]

The route Heisenberg had taken to this discovery was that of matrix mechanics, whereby mechanical laws are not written down as equations for the positions and velocities of the electrons but as equations for the frequencies and amplitudes of their Fourier expansions (the emitted radiation of an electron jump, by means of its frequencies and intensities, gives a picture of the electron orbit: this represents the Fourier expansion). It appears that matrix mechanics works in terms of waves. However, when converted to electron as particle (as demonstrated by Born, Jordan, and Dirac), the matrices representing position and momentum did not commute: this is the famous Uncertainty Principle, i.e. pairs of classical quantities cannot be fixed simultaneously with arbitrarily high accuracy. Of course, this goes entirely against the Newtonian grain, where those pairs of quantities can be fixed with very high accuracy. For example, in Newtonian mechanics, one could begin by measuring the position and velocity of a particular planet, and from those results, translated into mathematics and using the equations of motion, predict the properties of the system at a later time. This is impossible in quantum physics, since a high accuracy concerning the position of an electron necessitates a low one for the velocity.[101] But this is well known.

What concerns us here, in the face of an apparent contradiction, is Heisenberg's contention above that Newton's laws shine with the splendor of truth, that they draw the dedicated and devoted mind upward to a profound experience. In fact, as mentioned, they shone so brightly that it was difficult for the modern world to look beyond them; even Einstein, of all people, had difficulty looking beyond them. To demonstrate that Newtonian physics can still participate in the truth that the modern world knew it to have, Heisenberg turns to a re-interpretation of Kant, who was particularly affected by the shining truth of Newtonian physics, so much so that he judged the presuppositions of that system as synthetic a priori.[102] Some clarification is in order: Trying to discover if our knowledge is founded only in experience, Kant arrives at the conclusion that our knowledge is in part derived from experience and is in part a priori. To be a priori, a statement must state something with complete generality, with no imaginable exception. Analytic judgements, following from logic, and which if denied would lead to self-contradiction, are always a priori; Heisenberg illustrates this by noting that even if a child learns by playing with marbles that two and two is four, he does not always have to return to the marbles to know this. On the other hand, synthetic propositions are those which are not true by the meaning of component terms alone, but through observation, and are not self-contradicted when denied; empirical knowledge is

synthetic. What is interesting for our discussion is that Kant takes, in addition to the presuppositions of arithmetic and Euclidian geometry, those of Newtonian physics to be synthetic a priori judgements; that is, although we come to judgements of, say, space, time and causality through observation, it is impossible to imagine exceptions to those judgements - they are thought "a priori forms of pure intuition."[103]

In many ways, Kant's judgement of the presuppositions of Newtonian physics as synthetic a priori is a tribute to that system's 'splendor of truth'. However, the theory of relativity demonstrated that Newtonian concepts of space and time, which Kant did not perceive as 'concepts' at all, but intuitions, were in fact not a priori - there exist exceptions; obviously, quantum physics demonstrates even more exceptions. Thus, "the a priori concepts which Kant considered an undisputable truth are no longer contained in the scientific system of modern physics."[104] However, by no means does this annihilate completely Kant's concept of 'synthetic judgements a priori', since Newtonian mechanics, for Heisenberg, has met all the requirements of truth. Rather, Heisenberg would qualify Kant's concept in a very important way: in the realm of appropriate applicability, the concepts of Newtonian physics remain a priori.[105] That is, the concepts have been formed through our interaction with a specific part of the world: "the Kantian 'a priori' is indirectly connected with experience in so far as it has been

formed through the development of the human mind in a very distant past." He continues:

> Following this argument the biologist Lorentz has once compared the 'a priori' concepts with forms of behaviour that in animals are called 'inherited or innate schemes.' It is in fact quite plausible that for certain primitive animals space and time are quite different from what Kant calls our 'pure intuition' of space and time. The latter may belong to the species 'man', but not to the world as independent of men.[106]

Heisenberg's point here is simply that the concepts are relative, and he would likely continue that not only might humanity possess different concepts than some animals, but certainly that the concepts are relative in almost an historical sense: they will change in response to a changed situation or area of inquiry. Thus, he lays a good deal of stress on the fact that "the transition from one realm to another...from Newtonian physics to quantum theory, is not continuous, but discrete."[107] That is, in the first closed system, certain concepts are used and questions asked; in the second, old concepts become limited, new ones are introduced and different questions are asked. Of course, the structures realized through those 'relative' concepts are true; as Heisenberg said of Newton's laws, they will hold for the next hundred thousand years. They will never be dispensed with, and many of the concepts that generated them are in fact foundational to quantum physics; in this, then, the concepts should be referred to more as rich vehicles than relative intuitions. Earlier, Heisenberg's notions concerning the unfolding of structures through the unfolding of concepts was

discussed at length; therefore, that metaphor of a tapestry used in the last section, whereby the basic weaving action was essential to whole, no matter what newly colored or textured threads became necessary to the picture's completion, applies to the concepts of Newtonian physics:

> Even if we realize that the meaning of a concept is never defined with absolute precision, some concepts form an integral part of scientific methods, since they represent for the time being the final result of the development of human thought in the past, even in the very remote past; they may even be inherited and are in any case the indispensable tools for doing scientific work in our time. In this sense they can be practically a priori. But further limitations of their applicability may be found in the future.[108]

In case it should be forgotten that dialogue figured significantly in Heisenberg's thought, it must be mentioned that it was really Einstein, when Heisenberg was explaining to him some aspects of his theory of quantum mechanics, who first demonstrated this fact to Heisenberg, namely, that Newtonian concepts are indispensable tools for scientific work. The one point that caught Einstein's attention in Heisenberg's explanation was that although he assumed the existence of an electron inside the atom, Heisenberg refused to consider its orbit, and restricted himself only to the radiation emitted from the electron, from which could be deduced its frequencies and corresponding amplitudes - "since a good theory must be based on directly observable magnitudes...."

> "But you don't seriously believe," Einstein protested, "that none but observable magnitudes must go into a physical theory?"
>
> "Isn't that precisely what you have done with relativity?" I asked in some surprise...

> "Possibly I did use this kind of reasoning," Einstein admitted, "but it is nonsense all the same...It is the theory which decides what we can observe."[109]

By theory, Einstein means an assumption of natural laws, which first of all enables observation, and Heisenberg learns from Einstein that the bare datum of experience alone was not able to provide a basis for theories of natural laws. In fact, the theory comes first, that is, knowledge of natural laws determines what can be seen and understood of the phenomena:

> You must appreciate [Heisenberg recalls Einstein saying] that observation is a very complicated process. The phenomena under observation produce certain events in our measuring apparatus. As a result, further processes take place in the apparatus, which eventually and by complicated paths produce sense impressions and help us to fix the effects in our consciousness. Along this whole path - from the phenomenon to its fixation in our consciousness - we must be able to tell how nature functions, must know the natural laws in at least practical terms, before we can claim to have observed anything at all. Only theory, that is, knowledge of natural laws, enables us to deduce the underlying phenomena from our sense impression.[110]

Not only does theory enable observation, it in fact <u>constrains</u> that observation. Regarding both these aspects, Einstein gives Heisenberg the example of Heisenberg's own early work, pointing out that he does not work with only observable magnitudes. Heisenberg, he asserts, makes the assumption that things work according to established laws: "'You are, in fact, assuming that your theory does not clash with the old description of radiation phenomena in the essential points.'"[111] Hence, it was demonstrated to Heisenberg that theory does decide for him what can be observed; he has to have at least a basic <u>classical</u>

understanding of nature's workings, and of course the concepts through which that understanding is grasped, before he can make an observation. The observations must be made in conjunction with what is already known about nature, where the natural laws, the theory, is the point of reference. "I was completely taken back by Einstein's attitude, though I found his arguments convincing."[112]

Thus, although by closely following classical physics, those physicists, beginning with Planck, who found that nature was showing aspects of itself that could not possibly be understood in the exact terms of Newtonian physics, discovered that the concepts of Newtonian physics often remained the map by which they took their bearing. This might sound rather confusing, since it has been pointed out that the movement to quantum physics is a discrete one, yet now it is being claimed that no work could be done there without those concepts, and Heisenberg freely admits that the Copenhagen Interpretation of quantum physics starts from a paradox:

> Any experiment in physics, whether it refers to the phenomena of daily life or to atomic events, is to be described in the terms of classical physics. The concepts of classical physics form the language by which we describe the arrangement of our experiments and state the results. We cannot and should not replace these concepts by any others. Still the application of these concepts is limited by the relations of uncertainty. We must keep in mind this limited range of applicability of the classical concepts while using them, but we cannot and should not try to improve them.[113]

It is perhaps not unjustified to characterize this paradox with a changing style of art; in fact, if science was a painting, then the paradox could be better understood. For example, in Renaissance art, the rise of humanism required that the human body be studied anatomically, so that it could be represented in all its glory, e.g. the Creation of Adam, by Michelangelo. On the other hand, that same basically anatomically correct body, in Mannerism, is often characterized by distortion, restlessness, and imbalance, e.g., The Laocoon, by El Greco. It is the same human body, rippling with muscle, moving, but it is not at all the same body: it is used in a distinct way in each style. Of course, this is a simplistic example, and by no means a definite parallel, but hopefully it demonstrates the necessity of Newtonian concepts in something so completely different as quantum physics: in the first and second styles of physics and art, certain questions are being asked and answered. However, the questions in the second could not be asked or answered without the tools of the first. Obviously, though, the best illustration is found in the physics itself:

The Uncertainty Principle has already been mentioned above. It <u>does</u> deal with pairs of classical quantities, e.g., the position and velocity of a particle, though these concepts are modified by the uncertainty relations. Now, what is important to remember is that quantum mechanics does not demand less accuracy than Newtonian; that is, the uncertainty

does not mean a complete lack of knowledge about the pairs of quantities. Rather, it can be considered relatively well-defined: "the product of the uncertainties in the measured values of the position and momentum (i.e., the product of mass and velocity) cannot be smaller than Planck's constant;"[114] we are looking at a statistical spread, and it must be kept in mind that there are definite ranges. Now, if the following simplification be excused, it seems that the statistical spread is determined by the particle as wave, where the waves are not material waves, but those of "probability," not as a statement of our degree of knowledge of the actual situation, but probability as "a tendency for something." Heisenberg refers to it as a quantitative version of Aristotle's "potentia," and notes that probability "introduced something standing in the middle between the idea of an event and the actual event, a strange kind of physical reality just in the middle between possibility and reality."[115] More clearly, the probability was not that a particle would follow a certain trajectory, but that it would 'materialize' in a certain place; since one cannot speak in traditional terms of both position and velocity, one cannot speak of the Newtonian concepts of trajectory or orbit.

Although this mathematical formalism was for the most part accepted by physicists, the problem was the inability of physicists to determine how that formalism should be used to describe a given experimental situation. For example, one

could describe the stationary states of an atom (a description come to through many difficulties), yet one did not know how to describe what Heisenberg calls a much simpler event, an electron moving through a cloud chamber, an event certainly suggesting that Newtonian concepts were still fully valid, though somehow irreconcilable with quantum mechanics.[116] Recalling the importance of correspondence between theory and nature, this particular given experimental situation haunted Heisenberg: although the theory forbid a discussion of the electron's path, it seemed clear to the physicists that there indeed existed such a path, as observed in the cloud chamber. Still, the mathematical framework of quantum mechanics "was much too convincing to allow for any changes."[117] Literally agonizing over the problem, as were many other physicists, Heisenberg remembers Einstein's words, "It is the theory which decides what we can observe." Thus, Heisenberg turns the question around, and instead of asking how one can in the known mathematical scheme (let us call it the theoretical structure) express a given experimental situation, the question becomes: "is it true, perhaps, that only such experimental situations can arise in nature as can be expressed in the mathematical formalism?"[118] That is, rather than wondering how we can fit the empirical evidence into the theory, one should be emphasizing that only those experimental situations can occur that can be expressed in the theoretical structure - perhaps the ultimate Platonic realization. This,

of course, put an entirely new light on the situation, and Heisenberg considers this the point of rising out of the fog into the sunlight.

Taking a closer look at the cloud chamber experiment, Heisenberg notes that the physicists have been working with Newtonian assumptions. Rather than a 'path', all that could be seen was a series of discrete and ill-defined spots through which the electron had passed; actually, he continues, being more true to the evidence, all that is observed are individual droplets of water, which must be larger than the electron. Convinced by this that physics was not locked into a Newtonian approach, he interpreted the experiment through quantum mechanics, and discovered that it was in fact beautifully expressed through the theoretical structure of quantum mechanics. Again, though, the Newtonian approach is not negated.[119]

Heisenberg demonstrates the utter importance of Newtonian concepts in the following example of an experiment to discover such an electron's 'orbit,' the classical theoretical interpretation of which usually requires three steps. The first step is possible: "the translation of the initial experimental situation into a probability function,"[120] which itself combines objective and subjective statements, as in classical physics. Here, the necessary beginning is the recording of the electron's position and velocity in the initial observation, but taking into account the uncertainty

relations (inherent in the mathematical structure, and experimentally in the deflection of the electron by the photon of light used to observe it); again, this probability function "contains statements about possibilities or better tendencies ('potentia' in Aristotelian philosophy), and these statements are completely objective, they do not depend on the observer."[121] Further, the probability function also includes the probability of error in observation, which is also necessary in classical physics. The second classical step, "the following up of this function in the course of time,"[122] is impossible in this case, both theoretically, and equally important, experimentally: we are looking for the electron orbit, which is not allowed in the mathematical scheme, besides which, the photon has knocked the electron out of its orbit. One can thus never observe more than one point in the orbit of the electron. The next classical step would be a new measurement of the system, "the result of which can then be calculated from the probability function,"[123] and indeed, in this instance, the new measurement will conform to some point of probability. So, in quantum theory, the classical interpretation works in all but the second step, which concerns the question of "what happens" between the first and second measurement. Yet, perhaps 'works' is the wrong word, since the classical interpretation has done much more than simply function as a language (the <u>only</u> language, Heisenberg would argue) by which it is possible to discuss atomic

processes. Rather, the classical interpretation, and its limitations, has 'led' physics to the question of the second step, a question that has begun to reveal the nature of the basic structure of matter; the unfolding of concepts is the prerequisite of the unfolding of structures.

Let us review that point between observations. Heisenberg is clear that there is no such point. Take, as the physicist does, the observed phenomenon of a single photon moving through two holes and showing an interference pattern (i.e. the interference of two waves of light that creates bands of light on a photographic plate situated on the opposite side of the holes). Actually, Heisenberg would not talk about its movement, or its path. In his eyes, it is only possible to discuss the first measurement, with its probability function, and the final observation. If one were to discuss the path, one would have to use statements like the light went through either the first hole or the second; the statement is problematic and involves contradictions - it simply cannot be discussed. As Heisenberg says, "this example shows clearly that the concept of the probability function does not allow a description of what happens between two observations. Any attempt to find such a description would lead to contradictions: this must mean that the term "happens" is restricted to the observation."[124] This inability to discuss the motions of the particle is quite fascinating, especially since the whole experiment is framed in classical terms, but

that inability is unavoidable, both theoretically and experimentally. Nothing happens but in the observations. Potentials exist in the first, and the transition from the possible to the actual takes place during the second observation: "the observation itself changes the probability function discontinuously; it selects of all possible events the actual one that has taken place."[125] That is, it becomes actual in its interaction with the measuring device, or, since the device itself is part of the world, actuality materializes with its connection to the world.

Of course, it is at this point that many have, happily and unhappily, accused science of being a subjective enterprise, and Heisenberg is quick to assert that "quantum theory does not contain any genuine subjective features, it does not introduce the mind of the physicist as a part of the atomic event."[126] The connection is physical, not psychical. It needs only come into contact with the device, not our consciousness. Our knowledge does not change it, but it changes our knowledge (of the discontinuity of the probability function). For the purpose of our argument, this question is of no great importance, since for Heisenberg the necessary inclusion of our observations demonstrates that the subject/object assumption of Newtonian physics was merely a useful concept, which, for the most part, is of practical validity; the larger world can, for all intents and purposes, be scientifically separated into object and subject. In fact,

it is not an arbitrary concept, and Heisenberg understands the situation in physics to be this: "we wish to understand a certain phenomenon, we wish to understand how this phenomenon follows from the general laws of nature."[127] Thus, even in the atomic world it is necessary to attempt to separate the phenomena from the tools measuring it; that it cannot be done with classical success, that we cannot speak about the events without some reference to ourselves and our measuring devices, only shows the limitations to that idea of complete, total objectivity, which is a classical concept, not a reality. In this respect, quantum theory has not made a new discovery, but simply "reminds us, as Bohr has put it, of the old wisdom that when searching for harmony in life one must never forget that in the drama of existence we are ourselves both players and spectators."[128]

Through quantum theory, so many concepts are exploded, or better, so many "givens" are revealed as concepts, that books could and have been written on the philosophical and scientific ramifications. As interesting as they may be, it is impossible to reproduce them all here. The point thus far was simply to illustrate the richness of Newtonian concepts, derived from the archetypes and Ideas (recall that Newton found Kepler's law essential to his own theory, a law which Kepler admits was derived from an archetype), as they unfold and generate a new area of inquiry, where new structures can be re-cognized. Now it is necessary to discuss the structures

generated through the modified concepts of quantum mechanics, which is very much connected to that strange step where nothing 'happens'.

One facet of the Copenhagen Interpretation, contributed by Bohr, holds that there exist two complementary aspects of an elementary particle (EP), the wave and particle.[129] Yet, Heisenberg would argue, this does not accurately describe an EP, nor should it: the point is not to ask what the EP is (nor, especially, how it looks), but what it does, since our mathematical formalisms allow only this. Thus, the most accurate description is the mathematical probability function. But even then, the particle observed is not an elementary particle in itself, since, described by its probability function, an EP is "a possibility for being or a tendency for being."[130] Recall that an observation changes the probability function discontinuously; we are no longer "seeing" the elementary particle (since it is a tendency for being), but something that has actualized. By choosing an actual event, it has ceased being an EP (described by its probability function). So, one can say that the mathematical forms symbolizing elementary particles are "the ideas of the elementary particles on which the actual particles are modelled."[131] Thus, the mathematical elementary particle cannot be described as an object in itself, the Kantian Ding an sich;[132] rather, the mathematical elementary particle, in

a very important way, is a form, a structure, waiting for actuality through contact with the larger world.

Here, Heisenberg sees a genuine connection with Plato's elementary particles, which have thus far been referred to only in passing. As mentioned, Plato objected to the materialist doctrines of the atomists, and leaned heavily on his philosophy of Ideas in his works on physics. Assuming that the four basic elements were those of earth, water, air, and fire, Plato conceives the smallest particles of the element earth as cubes, those of water as icosahedrons, those of fire as tetrahedrons, and those of air as octahedrons: the form is thus characteristic of the properties of the element. However, unlike the atoms of Democritus, Plato does not imagine the smallest particles to be unalterable nor indestructible: "on the contrary they can be resolved into triangles and can be reconstructed from triangles."[133] Here, then, the smallest units of matter are not a-toms, since the triangles, having no spatial dimensions, themselves are no longer matter. Therefore,

> ...in Plato, at the lowest limit of the series of material structures, there is really no longer anything material, but a mathematical form if you like, an intellectual construct. The ultimate root from which the world can be uniformly understood is, in Plato, mathematical symmetry, the image, the idea.[134]

Though the conception of idea, or structure, is similar, there are yet problems. Plato had 'resolved' the physical problem of the "one" and the "many". Although Heisenberg had conceived the mathematical electron as an idea, he cannot

claim the same resolution: atoms are quite complicated after all, as we have seen. We have not yet touched upon the contents of the nucleus. As we know, the atoms of the basic elements can be understood as constructed of basically three elementary particles, that is, a certain number of protons and neutrons in the nucleus, and a certain number of electrons "orbiting" the nucleus. The electron, as we have seen, is not material in the Newtonian sense, but is a structure, waiting for actuality. However, although at the time Heisenberg had written Physics and Philosophy the dynamical laws for the electron had been understood (i.e. quantum mechanics), those for the nucleus had not yet been determined:

> In the nucleus the dynamic laws could well supposed to be just those of quantum mechanics, but the forces of the particles were not known beforehand; they had to be derived from the experimental properties of the nuclei. This problem has not yet been completely solved. The forces have probably not such a simple form as the electrostatic forces in the electronic shells and therefore the mathematical difficulty of computing the properties from complicated forces and the accuracy of experiments make progress difficult. But a qualitative understanding of the structure of the nucleus has definitely been reached.[135]

Certainly, it is most interesting, and telling of Heisenberg's convictions, that though the quantitative understanding was not resolved, he certainly expected it to follow along the same lines as the electron, which of course has a parallel in Platonic physics.

Note: As it happens, the proton and neutron were as difficult to understand as he expected. They appear to form co-operative assemblies within the nucleus, which led to the

development of the Rotational Model of the Nucleus, paralleling to a great extent the rotational model of the molecule. Today, it is thought that the proton and neutron are each composed of three quarks, which act much like mini-molecules within the nucleus; mesons in the nucleus are the equivalent of photons in the atom. The difference between the electron and the proton and neutron is that it is, as Heisenberg said, easier to study the electron - it is a single, solitary "object", and has a great deal of room in which to "move" around, or rather, there exists a great deal of "space" for our observations (the diameter of an atom is 10 cm). On the other hand, the proton is 10 cm; besides which, the proton is an aggregate of quarks, and thus, if one wanted to study the dynamics of a single quark, the diameter would be even less (our difficulty therefore increasing). Of course, at the moment, empirical data of single quarks is not available, since quarks have not been able to be split - nor even detected. Intriguingly, though electrons obey the inverse square law, it has been theorized that the force between quarks <u>increases non-linearly</u> in separation: thus, the harder one tries to separate them, the more closer quarks are bound by this force, which increases with distance. Apparently, the action is like one of a non-linear spring.[136] It would appear then, that at present, a full understanding of these quarks has not been reached, although it certainly seems that much research is being devoted to the problem.

Heisenberg would not be surprised by these intense efforts, and in his own day was quite aware of the scientific search for quarks; he attributed this search to the traditional prejudice in favour of Democritus:

> Many experimental physicists nowadays look for 'quark' particles, particles with a charge of one-third or two thirds the charge of the proton. I am convinced that the intense search for quarks is caused by the conscious or unconscious hope of finding the really elementary particles, the ultimate units of matter. But even if quarks could be found, from all that we know they could again be divided into two quarks and one anti-quark, etc. They would not be more fundamental than a proton.[137]

Of course, Heisenberg was far from uncompromising in his atomic understanding, refusing to hold only to the existence of three elementary particles (the electron, proton, and neutron); early accelerator experiments had demonstrated the existence of new elementary particles, with similar properties as the old ones, except for their instability. When Physics and Philosophy was written, physicists were aware of about twenty five different new elementary particles, with the negative proton cited by Heisenberg as the most recent. Thus, his objections were not against new particles, but in their nomination as the final "elementary" ones.

A quick discussion of Heisenberg's understanding of these accelerator experiments shows this clearly, especially in conjunction with his ideas reviewed above. The accelerating machine works thus: by means of a big magnetic field, charged particles are accelerated in circles, so that they can be pushed again and again by electric fields on their way around.

At very high energies, two elementary particles collide, and as a rule fall into often very many pieces, "but the pieces are no smaller than the particles that were split."[138] Thus, these experiments had demonstrated the existence of new elementary particles, with similar properties as the old ones, except for their instability. In other accelerator experiments, Heisenberg states that the same sort of particles there obtained are ones which physics had been familiar with for a number of years; no other or smaller particles have been found. Interestingly, "their charge...can be easily measured, and it is always equal to, or an integer multiple of, the charge of the electron."[139]

Two difficulties are finally solved for Heisenberg by this. The first deals with the above concern for the "elementariness" of particles: it was assumed that, after dividing the atom, and then the nucleus, that it would be possible to divide the elementary particles that compose it, that is, that matter was infinitely divisible. Now, matter had been proven divisible, but the particles were no more elementary than the ones collided. For Heisenberg, then, matter had shown itself to be infinitely divisible, yet at the same time it was obvious to him that there were smallest units of matter, that is, elementary particles did exist. He explains it thus: instead of stating that the colliding particles have been broken up, one should rather <u>assert the emergence of new particles from the collision energy, in</u>

accordance with the laws of the theory of relativity. We are left, then, not with elementary particles, but an elemental substance, from which elementary particles are created:

> The elementary particles in modern physics carry a mass in the same limited sense in which they have other properties. Since mass and energy are, according to the theory of relativity, essentially the same concepts, we may say that all elementary particles consist of energy. This could be interpreted as defining energy as the primary substance of the world. It has indeed the essential property belonging to the term "substance," that it is conserved.[140]

This is quite important. Recall that physics has as its goal some principle of unity in the infinite variety and mutability of the forms of matter; its task was to discover the fundamental features of matter which persist under all apparent changes. With the construction of and experiments with accelerators, the complete mutability of matter was shown once and for all to Heisenberg: at sufficiently high energies, elementary particles can be transmuted into other particles, or can simply be created from kinetic energy and can be annihilated into energy. However, in the discovery that all elementary particles are composed of the same substance, energy, or as Heisenberg calls it, 'universal matter' - "we have here actually the final proof for the unity of matter."[141] Qualitatively, he compares this situation with the Aristotelian concepts of matter and form: "we can say that the matter of Aristotle, which is mere 'potentia', should be compared to our concept of energy, which gets into 'actuality' by means of the form, when the elementary particle is

created."[142] Thus, the ancient pair of concepts, "substance and form" reappears, although substance cannot exist without form, possessing only potentia. He also draws an analogy to Heraclitus, in which fire is the fundamental substance of which the world is made, if fire can be substituted with "energy": "energy is in fact that which moves; it may be called the primary cause of all change, and energy can be transformed into matter or heat or light."[143] Again one observes the richness of concepts, no matter how ancient; one never knows their limits.

However, although a qualitative understanding of matter has been reached - that is, the fundamental substance, necessary for the existence of everything, is energy -, this understanding is not enough. As one commentator remarks, "this [fundamental substance] is what we understand in the Aristotelian sense as substantial form, namely that which must be to have form and matter, <u>that which by itself is not conceivable</u>, and yet is a prerequisite for material existence [emphasis added]."[144] It is rather in this sense that Heisenberg understands energy as potentia: as potentia, energy is potential matter, actualizing only as an observed particle, determined by some form. Thus, he cannot rest at the unifying principle of energy, since it provides only the substance, and not the form. Clearly, a fuller understanding is necessary:

> Modern physics is of course not satisfied with only qualitative description of the fundamental structure of matter; it must try on the basis of careful experimental investigations to get a mathematical formulation of those

> natural laws that determine the "forms" of matter, the elementary particles and their forces.[145]

To repeat, accelerator experiments have demonstrated that there exist smallest units of matter, created out of the fundamental substance of energy. The second difficulty following from this concerns the nature of the smallest units of matter, "whether they are ordinary physical objects, whether they exist in the same way as stones or flowers."[146] Of course, in view of the discussion above, it should be clear that Heisenberg does not conceive of them as material in the same way as stones or flowers; they are ideas, forms, and what we observe is not the elementary particle in itself. However, given that Heisenberg was well aware of the existence of a large amount of these particles, it is not surprising that his search for beauty continued, and he remained confident that a unifying principle would be found. In fact, he suggests an interesting analogy:

> ...the elementary particles are something like the stationary states of an atom or a molecule. There is a whole spectrum of particles, just as there is a spectrum, say, of the iron atom or a molecule, where we may think, in the latter case, of the various stationary states of a molecule, or even of the many different possible molecules of chemistry. Among particles, we shall speak of a spectrum of 'matter.'[147]

This seems to mean that each particle is a different state of a fundamental structure. Perhaps one could speak of the unfolding of the richness of the structure, and Heisenberg does seem to speak of the many particles in this way: "we have good reason to believe that these forms are all manifestations

of certain fundamental structures, that is, consequences of a mathematically expressible fundamental law of which the elementary particles are a solution..."[148] Thus, the particles, which are the limiting forms which actualize matter, are in reality different manifestations of perhaps a single structure: "these basic forms must in some way be determined by a fundamental law expressible in mathematical terms."[149]

Yet, although this certainly parallels Pythagorean/Platonic thought, Heisenberg makes an important clarification in his references to Platonic physics, one connected to the dynamical laws. The ancient Greeks thought in terms of static forms, and found them in the regular solids: "it was a question of a static, immediately intuitable symmetry."[150] Conversely, modern science has developed out from the dynamic problem, and thus, to repeat, "the constant element in physics since Newton is not a configuration or a geometrical form, but a dynamic law." Heisenberg tells us that the equation of motion is in a sense eternal, since it holds for all times, whereas the geometrical forms are changing. Though it is a problem which had not been solved in Heisenberg's day (nor in our own), he concludes positively that, given the "eternality" of the equation of motion, "the mathematical forms that represent the elementary particles will be solutions of some eternal law of motion for matter."[151] Another clarification he makes concerning the

similarities between the theories of modern physics and ancient Greek philosophy is that "the statements of modern physics are in some way meant much more seriously than the statements of ancient Greek philosophy."[152] Heisenberg believes that it simply never occurred to the ancients to single out some events in nature by experiment, to both study the details and discover the constant laws in continuously changing nature. But because of its use of this method, Heisenberg concludes that "modern science has from its beginning stood upon a much more modest, but at the same time much firmer, basis than ancient philosophy."[153]

However, in line with Platonic thought, the physicist believes that this fundamental law of motion will turn out as mathematically simple law (relative, one might suppose, to one's familiarity with physics). In a most illuminating statement, he adds: "It is difficult to give any good argument for this hope for simplicity - except for the fact that it has always been possible to write the fundamental equations in physics in simple, mathematical forms."[154] He notes that, although many physicists share this conviction, no convincing argument has yet been given to demonstrate that it will be so; certainly, the influence of Heisenberg's religious understanding on his scientific is rarely observed more clearly than in this faith. Continuing, it would appear that the mathematical law would be simple because the law is a simple one, or rather, because the mathematical form is

simple, the law must be. Heisenberg has definite ideas about the nature of this fundamental law, which cannot be neglected here, since they appear to be direct results of his Platonic thought; however, because of their complex scientific nature, they will only be briefly sketched.

Thus far, we have found a parallel between Heisenberg and the ancient Greeks in the conception of the smallest units of matter as "ideas;" the difference was the conception of these "ideas" as more dynamic than static (i.e., at base, he posits them as solutions for the fundamental law of motion). In the constantly changing world, the enduring element cannot be static forms, only laws; yet, he says, "the laws, too, are at bottom only more abstract mathematical forms, though they relate to both space and time."[155] However, the most profound parallel enters in Heisenberg's informed theorizing, based on accelerator experiments, on the nature of the fundamental law: "Like the regular bodies of Plato's philosophy, the elementary particles of modern physics are defined by the mathematical conditions of symmetry [emphasis added]."[156] Again, these symmetries are much too complex to be fully explained here, and Heisenberg himself admits that the symmetries of particle physics are largely unintuitable. It must be noted, though, that Heisenberg offered a very tentative equation of matter, which, besides using the three natural units of measure, contains nothing more than the mathematical requirements for symmetry, a few properties of which Heisenberg understands as

crucial: the inhomogeneous Lorentz group, the transformations in Hilbert space which leave the exchange-relations invariant, the so-called isospin group, and the group associated with the conservation of baryon number, and some important mirror symmetries, or the invariance of the theory under reversal of the time signs and under simultaneous spatial mirroring and charge reversal.[157] Yet, although this means little to the lay person, these symmetries hold an incredible fascination for the physicist, "for the particles of present day physics are representations of symmetry groups, so the quantum theory tells us, and to that extent they resemble the symmetrical bodies of the Platonic philosophy."[158] Elementary particles embody symmetry: they are the simplest representations of symmetry, yet they are merely the consequence of symmetry.[159] That is, the basic structure of matter is an image, an idea:

> For modern natural science there is no longer in the beginning the material object, but form, mathematical symmetry. And since mathematical structure is in the last analysis an intellectual content, we could say, in the words of Goethe's Faust, "In the beginning was the word" - the logos. To know this logos in all particulars and with complete clarity with respect to the fundamental structure of matter is the task of present-day physics and its unfortunately often complicated apparatus.[160]

Although Heisenberg realized that his proffered equation was a tentative one, and could well be incorrect, he is confident that a unified field theory will, in time, come to light; nature, in Heisenberg's eyes, was made to be understood. By no means would this mean an end to physics, for there exists the chance that other phenomena exist "that the

concepts of this idealization are unable to capture," for example, those found in biology: all biological objects consist of elementary particles, "but the concepts we use to describe biological processes, e.g., the concept of life itself, do not appear in our idealization; so there must be still further developments of physics in this direction."[161] There is a tremendous unity to nature, a great interconnectedness, that each part is intimately related to the next. Nonetheless, when a unified field theory does 'shine forth', one particular facet of physics will be complete, in the existence of another closed theory, through which another aspect of reality, of that great interconnectedness, is disclosed. Here, the following enlightening words of Heisenberg concerning the nature of these discrete disclosures closes off our own theory of closed theories, particularly in their relation to the world of art. He likens the formation of a closed theory to the formation of crystals; the theories, says he, take shape

> as if from a crystal nucleus, out of individual queries raised about experience, and which eventually, once the complete crystal has developed, again detach themselves from experience as purely intellectual structures that nonetheless forever illuminate the world for us. To that extent, amid all the differences, the history of the development of physics appears not unlike the history of other intellectual fields, for instance the history of art; for even in these other fields the concern is ultimately with no other goal than that of illuminating the world, even [if not especially] if it be the world within us, by means of intellectual constructs.[162]

Finally, and again as in art, this quest for understanding cannot continue in any fruitful way without the

compass of the one, the good and the true. As we have seen above, Heisenberg, following the classical tradition, makes a close link between beauty and the central order. When it comes to his view of science, his friend Carl von Weizsäcker notes, unsurprisingly, that "it has a decidedly aesthetic tone. Heisenberg explicitly acknowledges that the laws of nature are beautiful, and that symmetries are a form in which the beauty of the regularities of nature can be conceptually grasped and conceptually reflected."[163] In this context, then, that compass is faith in the beauty of nature; recall that for Heisenberg, the experience of the beautiful is the experience of understanding. Thus, Heisenberg unhappily notes the existence of "pessimists among particle physicists, who believe that there simply is no such law of nature, defining the dynamic properties of matter. With such a view I confess that I can make no headway at all."[164] The pessimistic view, states Heisenberg, would result in simply a grand tabulation of the maximum stationary states of matter, "and thus a compilation in which there is nothing more to understand, and which therefore, no doubt, would no longer be read by anyone."[165] It is in this way that science could lose its value as an avenue to religious understanding; however, Heisenberg insists, by way of theory, experimental correspondence and personal trust, that there is no reason for such pessimism.

Obviously, it should be clear from the above discussion that this trust in the beauty of nature must extend beyond the traditional trust, divorced as it is from its religious framework. Not only must the beauty be acknowledged, but it must be acknowledged as emanating from the central order; and in science, "the central order can be recognized by the fact that we can use such metaphors as 'Nature has been made according to this plan.' It is in this context that my idea of truth impinges on the reality of religious experience."[166] Again, the conception of that central order cannot be an antiseptic one, and indeed it is not for Heisenberg: "because my own experiences do not matter so much, I might go on to remind you of Pascal's famous text, the one he kept sewn in his jacket. It was headed 'Fire' and began with the words: 'God of Abraham, Isaac and Joseph - not of the philosophers and sages.'"[167] Of course, he hastens to add that, in that particular form, the text does not apply to him, since in addition to the three Biblical names, Heisenberg realizes that many other philosophers and sages have illuminated the living reality of the central order. Given this immense - and personal - reality, I believe it is possible to recover a term used in the last chapter, and say that even the scientist must be a 'lover' if he is to recognize the basic structures of reality. Certainly, Heisenberg never fails to point out the devotion and enormous work aimed at the understanding of atomic processes, the "care and craftsmanship" of a Bohr, the

"simplicity and perspicuous clarity" of work such as Planck's, the "excitement and fascination" of a Pauli, to name a few; Heisenberg often details the passionate discussions and deeply rooted convictions that characterized the development of the theory. If one is struck by anything at all in the reconstructed conversations of Physics and Beyond, it is Heisenberg's deliberate portrayal of the majority of physicists as 'lovers', for whom science was much more than an intellectual game. If it is not true in every case, then it is no less illuminating that Heisenberg believes it to be generally so. And though he would never say it of himself, there is little doubt that Heisenberg himself was one such lover; as Plotinus said of beauty - All perceive it. Not all are sharply stung by it. Only they whom we ever call lovers are.

Thus, in the end, Heisenberg returns to the immortal words, which, to the lover, are no longer merely words, but an expression of an experience: "God is a mathematician."[168] And though he qualifies this understanding by noting that it is the only understanding available through the language of science, since science, and thus physics, has consciously limited itself to the abstractions noted many times above, i.e. the recognition of the simple in the multiplicity of phenomena, and the use of mathematics to represent the phenomena, even this is saying a lot: a central order exists, which has formed the universe, or nature, in accordance with

mathematical principles; because those same structures are within our soul, it is possible to re-cognize them without, a recognition that causes those within to shine with a strong, new light. However, that those structures are brought forth through abstracted mathematical language constitutes the major difference between art and science: here, science can explain and make intelligible the basic structures, but the language is considered by Heisenberg to be devoid of the deeper values necessary to human existence: "The God here referred to is, however, an ordering God, of whom we do not know at once whether He is identical with the God to whom we turn in trouble, and to whom we can relate our life."[169] On the other hand, art presents - rather, it illuminates - the more complex structures which are the basis of human life: "every art would be worthless if it was no longer able to move men, no longer able to illumine for them the meaning of existence."[170] Art guided by the central order always remains for Heisenberg the clearest, most immediate way to religious understanding.

Nevertheless, an approach to the one can be made in terms of a precise scientific language, given that "our attention [is turned] to that centre of science described by Plato, in which the fundamental symmetries are to be found."[171] Here, the ability to see the connections, and make that statement concerning the intelligible forms, which is really of the same order as the structures of value, i.e. beauty, goodness, etc., assists the individual scientist in his/her approach to the

One; in fact, Heisenberg holds science's journey into abstraction as comparable to the spiritual journey into the interior that characterizes much of painting, music, poetry, and philosophy.[172] This abstracted science, and the connected technology, has led the world to that "initially uncanny emptiness and distance," and led it "not only with the mind but also with the heart."[173] Illustrating all that especially contemporary science has discovered through its interplay with nature, about both itself and nature, Heisenberg recalls Antoine de Saint-Exupery's little prince, "who looks after his small planet, cleans out the volcanoes and waters a rose, lives in that distance, but yet learns that 'On ne voit bien qu'avec le coeur, l'essentiel est invisible pour les yeux" ("We see well only with our hearts, the essential is invisible to the eyes").[174] In Platonic terms, the scientific, and human, realization of the structures of nature, made through the abstracted language of mathematics, is a springboard into the higher realm of Ideas:

> For the very broad connections become apparent in the basic structures, in the Platonic Ideas that thereby manifest themselves; and since these Ideas give tidings of the underlying total order, they may also, perhaps, be picked up by other areas of the human psyche than merely that of ratio - areas which themselves in turn stand in immediate relation to that total order, and hence also to the world of values.[175]

NOTES TO CHAPTER THREE

1.Heisenberg, Across the Frontiers, p. 117; Heisenberg, Schritte über Grenzen, p. 201: "Die Suche nach dem 'Einen,' nach der tiefsten Quelle alles Verstehen, ist wohl in gleicher Weise Ursprung von Religion und Wissenschaft gewesen."

2.Ibid., p. 146; Heisenberg, Schritte über Grenzen, p. 232: "Während die Wissenschaft erklärt, verständlich macht, soll die Kunst darstellen, erhellen, den Grund des menschlichen Lebens sichtbar machen."

3.Ibid., p. 106; Heisenberg, Schritte über Grenzen, p. 189: "Das erscheint zunächst als ein sehr natürlicher Ausgangpunkt für eine Welt, die ja aus Materie besteht."

4.Heisenberg, Physics and Philosophy, p. 60.

5.Heisenberg, The Physicist's Conception of Nature, p. 61; Heisenberg, Das Naturbild der heutigen Physik, p. 42: "...jedenfalls entstand schon damals in mir die Überzeugung, daß man kaum moderne Atomphysik treiben könne, ohne die griechische Naturphilosophie zu kennen..."

6.Ibid., p. 67.

7.Before and After Socrates, p. 68.

8."Platonic Natural Science in the Course of History," p. 7; in this connection, it is intriguing to recall Heisenberg's immense efforts after WWII to open up a genuine dialogue between the scientific and political communities. This will be looked at more closely in the next section.

9.The Republic, Book 6, p. 311; the translator of The Republic, W.H.D. Rouse, makes the interesting note that the root of hypotheses is "a placing under". He continues: "The words which follow seem to suggest an assault on a fortress wall, using steps and clinging to ropes or the backs of other men, reaching the top, and dropping down on the other side to finish the fight." This image of a significant and dynamic enterprise no doubt pleased Heisenberg, who conceived art, science and ethics - as paths to that deepest of understanding - to be vital, often arduous processes, that required strength of mind, purpose, and community.

10.Ibid., p. 232.

11.Heisenberg, Across the Frontiers, p. 116; Heisenberg, Schritte über Grenzen, p. 200: "Die gemeinsame Hoffnung von Demokrit und Plato war es gewesen, bei den kleinsten Einheiten der Materie dem

'Einen' nächer zu kommen, dem einheitlichen Prinzip, das den Lauf der Welt regelt."

12.De Caelo, II, 13, 293a, cited in Across the Frontiers, p. 172.

13.Marshall Clagett, Greek Science in Antiquity (New York: Collier Books, 1955), p. 84.

14.Heisenberg, Across the Frontiers, p. 172; Heisenberg, Schritte über Grenzen, p. 258: "...und so trennte sich der Weg zur Erkenntnis für lange Zeit von dem Weg zum Schönen."

15.Ibid.

16.Heisenberg, The Physicist's Conception of Nature, p. 84; Heisenberg, Das Naturbild der heutigen Physik, p. 58: "Die Naturwissenschaften sind ihm im Gegenteil ein Mittel zur Erhebung des Geistes, ein Weg Ruhe und Trost zu finden im Anschauen der ewigen Vollkommenheit der Schöpfung."

17.Kepler, Mysterium Cosmographicum, Dedication, cited in The Physicist's Conception Of Nature, p. 73.

18.Ibid., p. 77.

19.Ibid., p. 76.

20.Ibid.

21.Ibid., Chapter 2, p. 83.

22.Heisenberg, Across the Frontiers, p. 173.

23.Heisenberg, The Physicist's Conception of Nature, p. 84; Heisenberg, Das Naturbild der heutigen Physik, p. 58: "...die erstaunliche Verachtung des Empirischen."

24.Ibid.; Heisenberg, Das Naturbild der heutigen Physik, pp. 58-59: "...die auf Grund der Einsicht in die apriorischen Gründe viel zuverlässiger erfaßt werden können."

25.Ibid.; Heisenberg, Das Naturbild der heutigen Physik, p. 59: "Die vollkommene Übereinstimmung zwischen der Ordnung der 'Sinnesdinge' - die Werke Gottes sind - und den mathematischen und intelligiblen Gesetzen - den 'Gedanken' Gottes - wird zum Grundgedanken der 'Harmonices Mundi.' Platonische und neoplatonische Motive führen Kepler zu der Auffassung, daß das Lesen des Werkes Gottes - der Natur - nichts anderes sei als das Verhältnis der Quantitäten zu den geometrischen Gestalten zu erkennen. 'Die Geometrie, ewig wie Gott und aus dem göttlichen Geist hervorleuchtend, hat Gott die Bilder zur Ausgestaltung der

Welt geliefert, auf daß diese die beste und schönste, dem Schöpfer ähnlichste würde.'"

26.Ibid., p. 85; Heisenberg, Das Naturbild der heutigen Physik, pp. 59-60: "...die Natur schafft nicht erst die menschlichen Geister und dann die Dinge, damit diese ersten sich anpassen, sondern umgekehrt."

27.Galileo, Dialogue on the Two Chief Systems of the World, The First Day, cited in The Physicist's Conception of Nature, p. 93.

28.Ibid., p. 86; Heisenberg, Das Naturbild der heutigen Physik, p. 60: "Erst wenn die Voraussetzungen als Hypothese in der empirischen Erfahrung verwendet und dort bestätigt werden, gewinnen sie den Charakter der Naturgesetze."

29.For example, Galileo notes that Archimedes' statements about spirals "are not invalidated by the fact that no natural body exists to which such spiral motion could be attributed" (Letter to Carcarille, 5 June 1637.) As it happens, that logarithmic spiral illustrates the golden section, which has since been shown to the basic structural form of a great many natural existents. One is led to wonder, by this example, whether the assumptions by which we approach nature with are indeed drawn from a profound source. Further, one calls to mind Heisenberg's contention that we almost never know the limits of applicability of a concept.

30.Heisenberg, Across the Frontiers, p. 173; Heisenberg, Schritte über Grenzen, p. 259: "Aber er muß, und das ist ein entscheidender Punkt, um die Schönheit mathematischer Formen in den Erscheinungen wiederzuerkennen, die Tataschen idealisieren oder, wie Aristotles tandelnd formuliert hatte, sie verzerren."

31.Ibid.; Heisenberg, Schritte über Grenzen, p. 259: "Er gewann für diese Verzerrung der Tataschen, für diese Idealisierung, ein einfaches mathematisches Gesetz, und das war der Anfang der neuzeitlichen exakten Naturwissenschaft."

32.Heisenberg, The Physicist's Conception of Nature, p. 87; Heisenberg, Das Naturbid der heutigen Physik, pp. 60-61: "...es handelt sich nicht mehr um die Beobachtung der Natur schlechthin, sondern um eine Beobachtung, die von bestimmtem Prinzipien ausgeht und sich in ihrem Verlauf an ganze bestimmten Denkregeln orientiert. Das ist aber nicht anderes als die experimentelle Beobachtung, welch festellt, ob und wie weit bestimmte theoretische Auffassungen mit der Beobachtung übereinstimmen."

33.Ibid., p. 105; Heisenberg, Das Naturbild der heutigen Physik, pp. 74-75: "Bei Kepler ist die Naturwissenschaft noch ganz ungeschichtlich: mit Galilei wird sie geschichtlich, indem die Phänomene, die bestimmt werden sollen, nur innerhalb der von

Menschen festgelegten Voraussetzungen nach ihren Eigenschaften befragt werden."

34.Ibid.; Heisenberg, Das Naturbild der heutigen Physik, p. 75: "Innerhalb der einzelnen, vom Menschen von Fall zu Fall gesetzen Grenzen gibt die Natur allerdings immer die gleiche Antwort, und diese 'ewige,' eiserne Gesetzmäßigkeit wird nun Gegenstand der wissenschaftlichen Erbauung und ihre Erkenntnis bildet den Stolz des Naturwissenschaftlers" (note that "Stolz" has connotations of haughtiness and arrogance).

35.Cited in The Physicist's Conception of Nature, p. 112; Das Naturbild der heutigen Physik, p. 79.

36.It sometimes appears that the crisis of modernity is not the elevation of human ability, but its devaluation, and the elevation of that devalued state to the totality.

37.Heisenberg, The Physicist's Conception of Nature, p. 113; Heisenberg, Das Naturbild der heutigen Physik, p. 80: "Wer die Prinzipien der Naturlehre und die Gesetze der Dinge finden zu können glaubt, indem er sich allein auf die Kraft seines Geistes und das innere Licht seiner Vernunft stützt, muß entweder annehmen, die Welt sei aus einer Notwendigkeit hervorgegangen, und er muß die aufgestellten Gesetze aus derselben Notwendigkeit folgen lassen; oder er muß der Meinung sein, daß, wenn die Ordnung der Natur durch den Willen Gottes entstanden sei, er, ein elendes Menschlein, eingesehen habe, was als das Beste zu tun sei."

38.Note of H.S. Thayer, ed., Newton's Philosophy of Nature: Selections From His Writings (New York: Halfner Press, 1953), p. 184.

39.Heisenberg, Across the Frontiers, p. 174; Heisenberg, Schritte über Grenzen, p. 260: "Einige Jahrzehnte später hat Isaac Newton in England diesen Zusammenhang vollends freigelegt und in seinem großen Werk 'Philosophiae naturalis principia mathematica' im einzelnen beschrieben."

40.Ibid., 183; Heisenberg, Schritte über Grenzen, p. 269: "...und stellen wir fest, daß sie in der exakten Naturwissenschaft ebenso wie in den Künsten die wichtigste Quelle des Leuchtens und der Klarheit ist."

41.Heisenberg, Physics and Beyond, p. 31; Heisenberg, Der Teil und das Ganze, p. 50: "Aber hatte Ptolemäus das Planetensystem wirklich verstanden? Hat nicht erst Newton, der das Trägheitsgesetz kannte und die Kraft als Ursache für die Veränderung der Bewegungsgröße einführte, durch die Gravitation die Planetenbewegung wirklich erklärt? Hat nicht er als erster diese Bewegung verstanden?"

42.Newton, Principia, cited in The Physicist's Conception of Nature, p. 114.

43.Heisenberg, The Physicist's Conception of Nature, p. 115; Heisenberg, Das Naturbild der heutigen Physik, p. 81: "Newton hat eine Physik des Himmels geschaffen, ohne Willkür ohne Wunder, sich selbst erhaltend und in sich selbst ruhend, ohne damit in die Bahn des Materialismus geraten zu sein. Eh hält am Glauben an einen persönlichen Gott fest; der Naturmechanismus ist nur ein Mittel zur Erfüllung seiner Zwecke. Bleibt der 'große Ozean' der Wirklichkeit auch noch unentdeckt, so fügen sich die Einzelwahrheiten durch ihren Zusammenhang doch allmählich zu einem Ganzen...

44.Ibid., p. 180; Heisenberg, Das Naturbild der heutigen Physik, p. 132: "Die moderne Naturwissenschaft zeichnet sich in ihren Anfängen durch eine Bescheidenheit aus; sie macht über streng begrenzte Zusammenhänge Aussagen, die nur im Rahmen dieser Grenzen Gültigkeit haben.

45.Ibid.; Heisenberg, Das Naturbild der heutigen Physik, p. 180: "Die Erkenntnisse der Physik werden als Aussagen über die Natur als Ganzes betrachtet. Die Physik will Philosophie sein und verschiedentlich wird gefordert, daß jede wahre Philosophie Naturwissenschaft sein müsse."

46.Heisenberg, Physics and Philosophy, p. 72.

47.Ibid., p. 148.

48.Heisenberg, The Physicist's Conception of Nature, p. 127.

49.Ibid., p. 128.

50.D'Alembert, Traité de dynamique, cited in The Physicist's Conception of Nature, p. 129.

51.Encyclopédie ou Dictionnaire raisoné des sciences, arts, et métiers (1751), cited in The Physicist's Conception of Nature, p. 134.

52.Ibid., p. 130.

53.Ibid., p. 134.

54.Goethe's Letters to Zelter, ed. and tr. A.D. Coleridge, 1887; No. 47, p. 62, cited in Across the Frontiers, p. 127.

55.Across the Frontiers, pp. 131-132; Heisenberg, Schritte über Grenzen, p. 216: "Der entscheidende Einwand Goethes gegen die seit Newton angewandte Methodik der Naturwissenschaft richtet sich also wohl gegen das Auseinanderfallen der Begriffe 'Richtigheit' und 'Wahrheit' in dieser Methodik. Wahrheit war für Goethe vom

Wertbegriff nicht zu trennen. Das 'unum, bonum, verum,' das 'Eine, Gute, Wahre' war für ihn wie für die Philosophen der einzig mögliche Kompaß, nach dem die Menschheit sich beim Suchen ihres Weges durch die Jahrhunderte richten konnte."

56.Ibid., p. 141; Heisenberg, Schritte über Grenzen, p. 226: "Gleichzeitig sind die Gefahren so bedrohlich geworden, wie Goethe es vorausgesehen. Wir denken etwa an die Entseelung, die Entpersönlichung der Arbeit, an das Absurde der modernen Waffen oder an die Flucht in den Wahn, der die Form einer politischen Bewegung angenommen hatte. Der Teufel ist ein mächtiger Herr."

57.Ibid.; Heisenberg, Schritte über Grenzen, p. 226: "...ist auch in der modernen Naturwissenschaft sichtbar geworden, dort wo sie von der großen einheitlichen Ordnung der Welt Kunde gibt."

58.C.F. von Weizsäcker, "Platonic Natural Science", p. 4.

59.Heisenberg, The Physicist's Conception of Nature, p. 56; Heisenberg, Das Naturbild der heutigen Physik, p. 39: "Aber in einigen seltenen Fällen fängt ein Gegenstand, der so ins Blickfeld getreten ist, plötzlich an, im eigenen Licht zu leuchten, zunächst nur dunkel und undeutlich, dann immer heller, und schließlich füllt das von ihm ausgestrahlte Licht einen immer größeren Raum in unserem Denken, greift auf andere Gegenstände über und wird schließlich zu einem wichtigen Teil unseres eigenen Lebens...So ging es mir damals mit der Erkenntnis, daß die Mathematik auf die Dinge unserer Erfahrung paßt; eine Erkenntnis, die, wie ich in der Schule erfuhr, schon von den Griechen, von Pythagoras und Euklid, gewonnen worden war.

60.Ibid.; Heisenberg, Das Naturbild der heutigen Physik, p. 39: "Diesen Gedanken, daß die Mathematik in irgendeiner Weise auf Gebilde unserer paßt, empfand ich als außerordentlich merkwürdig und aufregend..."

61.Ibid., p. 57; Heisenberg, Das Naturbid der heutigen Physik, p. 40: "...es wäre mir nicht in den Sinn gekommen, die Naturwissenschaft und Technik unserer Zeit als eine grundsätzlich andere Welt als die Philosophie des PYTHAGORAS oder EUKILD anzusehen."

62.Ibid., p. 59; Heisenberg, Das Naturbid der heutigen Physik, p. 40: "...wenn sie eine so kompliziertr Gestalt haben, daß sie sogar Haken und Ösen besitzen, dann können sie unmöglich die kleinsten, unteilbaren Bausteine der Materie sein."

63.Heisenberg, Physics and Beyond, p. 2; Heisenberg, Der Teil und das Ganze, p. 13: "Denn Haken und Ösen sind, wie mir schien, recht willkürliche Gebilde, denen man je nach der

technischen Zweckmäßigkeit die verschiedensten Formen geben kann. Die Atome aber sollten doch eine Folge der Naturgesetze sein und durch die Naturgesetze veranlaßt werden, sich zu Molekülen zusammenzuschließen."

64.Ibid., p. 3; Heisenberg, Der Teil und das Ganze, p. 14: "Er hat Haken und Ösen gezeichnet, um möglichst drastisch darzutun, daß es Formen gibt, die zur Bindung von zwei, aber nicht von drei Sauerstoffatomen an das Kohlenstoffatom führen können."

65.Ibid., p. 4; Heisenberg, Der Teil und das Ganze, p. 16: "...sie sind die Voraussetzung für die Erfahrung."

66.Ibid., p. 8; Heisenberg, Der Teil und das Ganze, p. 21: "Dabei ging für mich von der Vorstellung, daß man bei den kleinsten Teilen der Materie schließlich auf mathematische Formen stoßen sollte, eine gewisse Faszination aus. Ein Verständnis des fast unentwirrbaren und unübersehbaren Gewebes der Naturerscheinungen war doch wohl nur möglich, wenn man mathematische Formen in ihm entdekken konnte. Aber mit welchem Recht Plato dabei gerade auf die regulären Körper der Stereometrie verfallen war, blieb mir völlig unverständlich."

67.Heisenberg does not share Kepler's disdain of empirical fact, and is quite in line with the modern directive that only such statements can be made that have been verified or can be verified by experiment. His understanding of the relationship between theory and experiment will be discussed below.

68.Heisenberg, Physics and Philosophy, p. 75.

69.Heisenberg, Physics and Beyond, p. 12; Heisenberg, Der Teil und das Ganze, p. 25: "...so kann das Wort Form hier nur in seiner allgemeinsten Bedeutung verstanden werden, als Struktur in Raum und Zeit, als Symmetrie-Eigenschaft von Kräften, als Möglichkeit zur Bindung an andere Atome."

70.Ibid., p. 13; Heisenberg, Der Teil und das Ganze, p. 25: "Anschaulich würde man solche Strukturen wohl nie beschreiben können, schon weil sie gar nicht so eindeutig in die objektive Welt der Dinge gehörten."

71.Ibid., p. 13; Heisenberg, Der Teil und das Ganze, p. 26: "Aber ich würde vermuten, daß sich die Gebilde, mit denen man dann zu tun bekommt, einer objektiven Fixierung in vorstellbaren Bildern weitgehend entziehen, daß sie eher eine Art abstrakter Ausdruck für die Naturgesetze sind, aber eben keine Dinge."

72.Ibid., p. 68; Heisenberg, Der Teil und das Ganze, pp. 98-99: "Ich glaube ebenso wie Sie, daß die Einfachheit der Naturgesetze einen objektiven Charakter hat, daß es sich nicht nur um Denkökonomie handelt. Wenn man durch die natur auf mathematische Formen von großer Einfachheit und Schönheit geführt wird - mit Formen meine ich hier: geschlossene Systeme von grundlegenden Annahmen, Axiomen und dergleichen - auf Formen, die bis dahin noch von niemandem ausgedacht worden sind, so kann man eben nicht umhin zu glauben, daß sie 'wahr' sind, das heißt daß sie einen echten Zug der Natur darstellen."

73.Ibid.; Heisenberg, Der Teil und das Ganze, p. 98: "Es mag sein, daß diese Formen auch von unserer Beziehung zur Natur handeln, daß es in ihnen auch ein Element von Denkökonomie gibt."

74.Ibid.; Heisenberg, Der Teil und das Ganze, p. 98: "Aber da man ja von selbst nie auf diese Formen gekommen wäre, da sie uns durch die Natur erst vorgeführt worden sind, gehören sie auch zur Wirklichkeit selbst, nicht nur zu unseren Gedenken über die Wirklichkeit."

75.Heisenberg, Encounters with Einstein, p. 9.

76.Ibid.; perhaps Heisenberg might say that, in a way, scientists are still seeking truth, though they know it not, and not knowing the path they follow, will not recognize their destination; although the divine spark is in all, only the lover, who knows the direction of his beloved, will recognize the profound path he takes.

77.Physics and Beyond, p. 69; Heisenberg, Der Teil und das Ganze, p. 99: "Sie können mir vorwerfen, daß ich hier ein ästhetisches Wahrheitskriterium verwende, indem ich von Einfachheit und Schönheit spreche. Aber ich muß zugeben, daß für mich, das uns hier von der Natur suggeriert worden ist, eine ganz große Überzeugungskraft ausgeht. Sie müssen das doch auch erlebt haben, daß man fast erschrikt vor der Einfachheit und Geschlossenheit der Zusammenhänge, die die Natur auf einmal vor einem ausbreitet und auf die man so gar nicht vorbereitet war."

78.Ibid., pp. 98-99; Heisenberg, Der Teil und das Ganze, pp. 138-139.

79.Heisenberg, Physics and Philosophy, p. 93.

80.Ibid.

81.Heisenberg, Physics and Beyond, p. 96; Heisenberg, Der Teil und das Ganze, p. 135: "Ich glaube, daß man die Newtonsche Mechanik überhaupt nicht verbessern kann; und damit meine ich folgendes: Sofern man irgendwelche Erscheinungen mit den Begriffen der Newtonschen Physik, nämlich Ort, Geschwindigkeit, Beschleunigung, Masse, Kraft usw. beschreiben kann, so gelten auch die Newtonschen Gesetze in aller Strenge, und daran wird sich auch in den nächsten hunderttausend Jahren nichts geändert habe."

82.Ibid.; Heisenberg, Der Teil und das Ganze, p. 135, "Es genügt festzustellen, daß innerhalb der Meßgenauigkeit die Newtonsche Mechanik wirklich gilt und auch in Zukunft gelten wird."

83.Ibid., p. 97; Heisenberg, Der Teil und das Ganze, p. 136: "Es gibt keine Experimente, die sie [Änderungen] nahelegten. Darin besteht eben der immer noch gültige Absolutheitsanspruch der Newtonschen Physik, daß sie in ihrem Anwendungsbereich nicht durch kleine Abänderungen verbessert werden kann, daß sie hier längst ihre endgültige Form gefunden hat."

84.Heisenberg, Across the Frontiers, p. 172; Heisenberg, Schritte über Grenzen, p. 258, "Die reine mathematische Spekulation wird unfruchtbar, weil sie aus einem Spiel mit der Fülle der möglichen Formen nicht mehr zurückfindet zu den ganz wenigen Formen, nach denen die Natur wirklich gebildet ist."

85.Heisenberg, Physics and Beyond, p. 69; Heisenberg, Der Teil und das Ganze, pp. 99-100.

86.Heisenberg, Across the Frontiers, p. 172; Heisenberg, Schritte über Grenzen, p. 258: "Und die reine Empirie wird unfruchtbar, weil sie schleißlich in endlosen Tabellenwerken ohne inneren Zusammenhang erstickt. Nur aus der Spannung, aus dem Spiel zwischen der Fülle der Tataschen un den veilleicht dazu passenden mathematischen Formen können die entscheidenden Fortschritte kommen."

87.Heisenberg, Physics and Beyond, p. 69; Heisenberg, Der Teil und das Ganze, p. 99: "Das Gefühl, das einem bei einem solchen Anblick überkommt, ist doch völlig verschieden etwa von der Freude, die man empfindet, wenn man glaube, ein Stück (phyikalischer oder nichtphysikalischer) Handwerksarbeit besonders gut geleistet zu haben."

88.Ibid., p. 99; Heisenberg, Der Teil und das Ganze, p. 139: "Wenn man, wie man es in der theoretischen Physik ja zunächst immer tun muß, die Ergebnisse von Experimenten in Formeln zusammenfaßt und so zu einer phänomenologischen Beschreibung der Vorgänge kommt, so hat man das Gefühl, daß man diese Formeln selbst erfunden hat, mit mehr oder weniger

befriedigendem Erfolg erfunden hat. Wenn man aber auf diese ganz einfachen großen Zusammenhänge stößt, die scheißlich in der Axiomatik fixiert werden, so sieht das ganz anders aus. Da erscheint vor unserem geistigen Auge auf einmal ein Zusammenhang, der auch ohne uns immer schon dagewesen und der ganz offensichtlich nicht von Menschen gemacht ist. Solche Zusammenhänge sind doch wohl der eigentliche Inhalt unserer Wissenschaft. Nur wenn man die Existenz solcher Zusammenhänge ganz in sich aufgennomen hat, kann man unsere Wissenschaft wirklich verstehen."

89.Heisenberg, Across the Frontiers, p. 164; Heisenberg, Schritte über Grenzen, p. 250: "Nur wen sich bemüht, so wenig wie möglich zu ändern, kann Erfolg haben, weil er dadurch den Sachzwang sichtbar macht; und die kleinen Änderüngen, die er schließlich als absolut notwendig erweist, erzwingen dann vielleicht im Laufe der Jahre oder Jahrzehnte eine Änderung in der Struktur des DEnkens, also eine Verschiebung in den Fundamenten."

90.Ibid., p. 159; Heisenberg, Schritte über Grenzen, p. 244: "Schließlich entdeckte er zu seinem Schrecken, daß er zur Deutung dieser Strahlung eine Hypothese machen mußte, die nicht in den Rahmen der klassischen Physik paßte, die vom Standpunkt dieser alten Physik her eigentlich völlig verrückt aussah."

91.Heisenberg, Physics and Philosophy, p. 31.

92.This information was taken generally from Heisenberg's works, as well from the works of other authors, most of which are listed in the bibliography below.

93.Heisenberg, Physics and Beyond, p. 59; Heisenberg, Der Teil und das Ganze, pp. 86-87: "Im Tal war damals das Wetter trüb gewesen, die Berge tief von Wolken verhangen; beim Aufstieg hatte sich Nebel immer dichter um unseren enger werdenden Pfad geschlossen, und nach einiger Zeit waren wir in ein völlig unübersichtliches Gewirr von Felsen und Latschen geraten, in dem wir beim besten Willen keinen Weg mehr erkennen konnten. Wir versuchten trotzdem an öhe zu gewinnen, allerdings mit etwas bangen Gefühlen, ob wir im Notfall wenigstens den Rückweg noch finden könnten. Aber mit dem weiteren Steigen ergab sich eine merkwürdige Veränderung. Der Nebel wurde stellenweise so dicht, daß wir die anderen aus dem Blickfeld verloren und uns nur noch durch Rufen verständigen konnten. Aber gleichzeitig wurde es über uns heller. Die Helligkeit fing an zu wechseln. Wir waren offenbar in ein Feld ziehender Nebelschwaden gelangt, und mit einem Mal konnten wir zwischen zwei dichteren Schwaden die helle, von der Sonne beleuchtete Kante einer hohen Felswand erkennen, deren Existenz wir nach unserer Karte schon vermutet hatten. Einige wenige

Durchblicke dieser Art genügten, um uns ein klares Bild der Berglandschaft zu vermittlen, die wahrscheinlich vor uns und über uns lag; und nach weiteren zehn Minuten scharfen Anstiegs standen wir auf einer Sattelhöhe über dem Nebelmeer in der Sonne. Im Süden waren die Spitzen des Sonnwendgebirgs und dahinter die Schneegipfel der Zentralalpen in voller Klarheit zu erkennen, und über unseren weiteren Aufstiegsweg gab es keinerlei Zweifel."

94.Ibid., p. 61; Heisenberg, Der Teil und das Ganze, p.: "Daher wurde es fast drei Uhr nachts, bis das endgültige Ergebnis der Rechnung vor mir lag. Der Energiesatz hatte sich in allen Gliedern als gültig erwiesen, und - da dies ja alles von selbst, sozusagen ohne jeden Zwang herausgekommen war - so konnte ich an der mathematischen Widerspruchsfreiheit und Geschlossenheit der damit angedeuteten Quantenmechanik nicht mehr zweifeln. Im ersten Augenblick war ich zutiefst erschrocken. Ich hatte das Gefühl, durch die Oberfläche der atomaren Erscheinungen hindurch auf einen tief darunter liegenden Grund von merkwürdiger innerer Schönheit zu schauen, und es wurde mir fast schwindlig bei dem Gedanken, daß ich nun dieser Fülle von mathematischen Strukturen nachgehen sollte, die die Natur dort unten vor mir ausgebreitet hatte."

95.Ibid., p. 101; Heisenberg, Der Teil und das Ganze, p. 142: "...die Natur ist, das war meine Überzeugung, so gemacht, daß sie verstanden werden kann. Oder vielleicht sollte ich richtiger umgekehrt sagen, unser Denkvermögen ist so gemacht, daß es die Natur verstehen kann."

96.Heisenberg, Across the Frontiers, p. 174; Heisenberg, Schritte über Grenzen, p. 261: "...Aufleuchten des großen Zusammenhangs..."

97.Ibid., p. 182; Heisenberg, Schritte über Grenzen, p. 268: "Es ist das staunende Erschrecken,...mit dem die Seele sich gleichsam an etwas zurückerinnert, was sie unbewußt doch immer schon besessen hatte."

98.Ibid., p. 182; Heisenberg, Schritte über Grenzen, p. 268: "In Atomphysik hat sich dieser Vorgang vor nicht ganz fünfzig Jahren abgespielt und hat die exackt Naturwissenschaft wieder in den Zustand harmonischer Geschlossenheit unter ganz neuen Voraussetzungen zurückgebracht, der für ein Vierteljahrhundert verlorengegangen war."

99.Heisenberg, Encounters With Einstein, p. 3.

100.Heisenberg, Physics and Beyond, p. 195; Heisenberg, Der Teil und das Ganze, p. 166: "Wenn wir die Entwicklung der Wissenschaft in deiser Weise als einen historischen Prozeß im Weltmaßstab ansehen, so erinnert deine Frage an das alte

Problem von der Rolle des Individuums in der Weltgeschichte. Sicher wird man hier annehmen müssen, daß die Individuen im Grunde weitgehend ersetzbar sind. Wenn Einstein nicht die Relativitätstheorie entdeckt hätte, so wäre sie früher oder später von anderen...formuliert worden."

101.Physics and Philosophy, chapters 2 and 3.

102.See chapter five, "The Development of Philosophical Ideas Since Descartes in Comparison with the New Situation in Quantum Theory," in Physics and Philosophy; see also chapter ten, "Quantum Physics and Kantian Philosophy," in Physics and Beyond, chapter ten, "Quantenmechanik und Kantsche Philosophie," in Der Teil und das Ganze.

103.Heisenberg, Physics and Philosophy, p. 87.

104.Ibid., p. 90.

105.Ibid., p. 92.

106.Ibid., p. 91.

107.Heisenberg, Physics and Beyond, p. 98; Heisenberg, Der Teil und das Ganze, p. 138: "...daß der Übergang von einem Bereich zum anderen, etwa von der Newtonschen Physik zur Quantentheorie, nicht kontinuierlich, sondern gewissenmaßen unstetig erfolgt..."

108.Heisenberg, Physics and Philosophy, p. 92.

109.Heisenberg, Physics and Beyond, p. 63; Heisenberg, Der Teil und das Ganze, pp. 91-92: "Da es aber doch vernünftig ist, in eine Theorie nur die Größen aufzunehmen, die beobachtet werden können...

'Aber Sie Glauben doch nicht im Ernst,' entgegnete Einstein, 'daß man in eine physikalische Theorie nur beobachtbare Größen aufnehmen kann.'

'Ich dachte,' fragte ich erstaunt, 'daßgerade Sie diesen Gedanken zur Grundlage Ihrer Relativitätstheorie gemacht hätten?'...

'Vielleicht habe ich diese Art von Philosophie benützt,' antwortete Einstein, 'aber sie ist trotzdem Unsinn.'"

110.Ibid., p. 64; Heisenberg, Der Teil und das Ganze, p. 92: "Sehen Sie, die Beobachtung ist ja im allgemeinen ein sehr komplizierter Prozeß. Der Vorgang, der beobachtet werden soll, ruft irgendwelche Geschehnisse in unserem Meßapparat hervor. Als Folge davon laufen dann in deisem Apparat weitere Vorgänge ab, die schließlich auf Umwegen den sinnlichen Eindruck und die Fixierung der Ergebnisses in unserem Bewußtsein bewirken. Auf diesem ganzen langen Weg vom Vorfang

bis zur Fixierung in unserem Bewußtsein müssen wir wissen, wie die Natur funktioniert, müssen wir die Naturgesetze wenigstens praktisch kennen, wenn wir behaupten wollen, daß wir etwas beobachtet haben. Nur die Theorie, das heißt die Kenntnis der Naturgesetze, erlaubt uns also, aus dem sinnlichen Eindruck auf den zugrunde liegenden Vorgang zu schließen."

111.Ibid.; Heisenberg, Der Teil und das Ganze, p. 93: "Sie vermuten, daß Ihre Theorie die bisherige Beschreibung der strahlungsvorgänge in den Punkten, auf die es Ihnen hier ankommt, unangetastet läßt."

112.Ibid.; Heisenberg, Der Teil und das Ganze, p. 93: "Mir war diese Einstellung Einsteins sehr überraschend, obwohl mir seine Argumente einleuchteten..."

113.Heisenberg, Physics and Philosophy, p. 44.

114.Heisenberg, Physics and Beyond, p. 78; Heisenberg, Der Teil und das Ganze, p. 112: "Das Produkt der Unbestimmtheiten für Ort und Bewegungsgröße (unter Bewegungsgröße versteht man das Produkt aus Masse und Geschwindigkeit) kann nicht kleiner als das Plancksche Wirkungsquantum sein."

115.Heisenberg, Physics and Philosophy, p. 41.

116.Heisenberg, Physics and Beyond, p. 78; Heisenberg, Der Teil und das Ganze, p. 111.

117.Ibid., p. 77; Heisenberg, Der Teil und das Ganze, p. 111: "Das mathematische Schema der Quantenmechanik gab es auch, und es war viel zu überzeugend um noch Änderungen zuzulassen."

118.Heisenberg, Physics and Philosophy, p. 42.

119.Heisenberg, Physics and Beyond, p. 78; Heisenberg, Der Teil und das Ganze, pp. 111-112.

120.Heisenberg, Physics and Philosophy, p. 46.

121.Ibid., p. 53.

122.Ibid., p. 46.

123.Ibid.

124.Ibid., p. 52.

125.Ibid., p. 54.

126.Ibid., p. 55.

127.Ibid., p. 57.

128.Ibid., p. 58.

129.For various reasons, physicists were inclined to hold a wave interpretation of atomic processes, which completely disregarded the quantum discontinuity. Bohr realized that both pictures, that of the wave and the particle, were essential to a full understanding of the EP; "as any of these descriptions can only be partially true, there must be limitations to the use of the particle concept as well of the wave concept, else one could not avoid contradictions. If one takes into account those limitations which can be expressed by the uncertainty relations, the contradictions disappear" (Physics and Philosophy, p. 43).

130.Ibid., p. 70.

131.Heisenberg, Physics and Beyond, p. 245; Heisenberg, Der Teil und das Ganze, p. 332: "...sie sind...die Ideen der Elementarteilchen, denen dann schleißlich das Objekt Elementarteilchen entspricht."

132.Ibid., p. 123; Heisenberg, Der Teil und das Ganze, p. 171.

133.Heisenberg, "Planck's discovery...", p. 6.

134.Ibid.

135.Heisenberg, Physics and Philosophy, p. 157.

136.See Frank Close, "The Quark Structure of Matter," in The New Physics, ed. by Paul Davies (Cambridge: Cambridge University Press, 1989).

137.Heisenberg, "Tradition in Science," p. 55.

138.Heisenberg, Across the Frontiers, p. 115; Heisenberg, Schritte über Grenzen, p. 199: "Wenn zwei Elementarteilchen mit extrem hoher Energie zusammenstoßen, so gehen sie in der Tat in der Regel in Stücke, manchmal sogar in viele Stücke, aber die Stücke sind nicht kleiner als die Teilchen, die zerlegt worden sind."

139.Ibid.; Heisenberg, Schritte über Grenzen, p. 199: "Ihre Ladung zum Beispiel kann leicht gemessen werden und ist stets ein ganzzahliges Vielfaches oder gleich der Ladung des Elektrons."

140.Heisenberg, Physics and Philosophy, p. 71.

141.Ibid., p. 160.

142.Ibid.

143.Ibid., p. 71.

144. Hans-Guenther Listfeldt, "Some Concepts of Matter of Avicenna, Averroes, St. Thomas and Heisenberg," Aquinas (Rome), vol. 18, 1974, p. 318.

145.Heisenberg, Physics and Philosophy, p. 160.

146.Heisenberg, Across the Frontiers, p. 114; Heisenberg, Schritte über Grenzen, p. 198: "Diese zweite Schwierigkeit bezieht sich auf die Frage, ob die kleinsten Einheiten gewöhnliche physikalische Objekte sind, ob sie in der Gleichen Weise existieren wie Steine oder Blumen."

147.Heisenberg, Encounters with Einstein, p. 74.

148."...in the same manner as the various energy states of the hydrogen atom represent the solution of Schrodinger's differential equation." Heisenberg, "Planck's Discovery...," p. 16.

149.Ibid.

150.Heisenberg, Across the Frontiers, p. 26; Heisenberg, Schritte über Grenzen, p. 39: "Es handelt sich also dort um eine statische, unmittelbar anschauliche Symmetrie."

151.Heisenberg, Physics and Philosophy, p. 72.

152.Ibid., p. 74.

153.Ibid.

154.Ibid., p. 73.

155.Heisenberg, Across the Frontiers, p. 26; Heisenberg, Schritte über Grenzen, p. 39: "Die Gesetze sind allerdings im Grunde auch nur abstraktere mathematische Formen, die sich aber eben auf Raum und Zeit beziehen."

156.Heisenberg, "Planck's discovery...," p. 19.

157.Heisenberg, Across the Frontiers, pp. 25-28; Heisenberg, Schritte über Grenzen, pp. 38-42.

158.Heisenberg, Encounters with Einstein, p. 83.

159.Heisenberg, Physics and Beyond, p. 240; Heisenberg, Der Teil und das Ganze, p. 325.

160.Heisenberg, "Planck's Discovery...," p. 19.

161.Heisenberg, Across the Frontiers, pp. 189-190; Heisenberg, Schritte über Grenzen, pp. 275-276: "...es mag doch noch andere Erscheinungen geben, die nicht mit den Begriffen dieser Idealisierung erfaßt werden können. Der augenfälligste Beweis für diese Möglichkeit ist die Biologie. Denn zwar bestehen auch alle biologischen Objekte aus Elementarteilchen; aber die Begriff, mit denen wir biologische Vorgänge zu beschreiben pflegen, z.B. der Begriff Leben selbst, kommen in jener Idealisierung nicht vor; also muß es noch weitere Entwicklungen der Physik in dieser Richtung geben."

162.Ibid., pp. 45-46; Heisenberg, Schritte über Grenzen, p. 80: "Diese Entwicklung erscheint uns als eine Folge geistiger Strukturen, 'geschlossener Theorien,' die sich aus einzelnen Fragestellungen über die Erfahrung wie aus einem Kristallkeim bilden und die sich schließlich, wenn der volle Kristall entstanden ist, als rein geistige Gebilde wieder von der Erfahrung ablösen; die aber doch für alle Zeiten die Welt für uns erhellen. Insofern erscheint bei aller Verschiedenheit die Entwicklungsgeschichte der Physik nicht unähnlich der Geschichte anderer geistiger Bereiche, etwa der Geschichte einer Kunst; denn auch in den anderen Bereichen handelt es sich letzten Endes um kein anderes Ziel als darum, die Welt, und sei es die in unserem Innern, durch geistige Strukturen zu erhellen."

163.Weizsäcker, "Platonic Natural Science in the Course of History," p. 4.

164.Heisenberg, Encounters with Einstein, p. 89.

165.Ibid.

166.Heisenberg, Physics and Beyond, p. 215; Heisenberg, Der Teil und das Ganze, p. 292: "In der Naturwissenschaft ist die zentrale Ordnung daran zu erkennen, daß man schließlich solche Metaphern verwenden kann wie 'die Natur ist nach diesem Plan geschaffen.' Und an dieser Steele ist mein Wahrheitsbegriff mit dem in den Religionen gemeinten Sachverhalt verbunden."

167.Ibid.; Heisenberg, Der Teil und das Ganze, p. 293: "Und ich könnte, weil es ja auf meine persönlichen Erlebnisse hier nicht ankommt, an den berühmten Text erinnern, den Pascal immer bei sich trug und den er mit dem Wort 'Feuer' begonnen hatte..."

168.Heisenberg, Across the Frontiers, p. 120; Heisenberg, Schritte über Grenzen, p. 205, "Gott ist ein Mathematiker."

169.Ibid., p. 215; Heisenberg, Schritte über Grenzen, pp. 301-302: "Allerdings, der Gott, von dem hier geredet wird, ist ein ordnender Gott, einer, von dem wir nicht sogleich wissen, ob er identisch ist mit jenem, an den wir uns in unserer Not wenden, auf den wir unser Leben beziehen können."

170.Ibid., p. 88; Heisenberg, Schritte über Grenzen, p. 169: "...jede Kunst wäre wertlos, die die Menschen nicht mehr zu bewegen, ihnen den Sinn des Daseins nicht mehr zu erhellen vermöchte."

171.Ibid., p. 120; Heisenberg, Schritte über Grenzen, p. 205: "Wenn man sich dem 'Einen' in den Begriffen einer präzisen wissenschaftlichen Sprache nähern will, so muß man das schon von Plato beschriebene Zentrum der Naturwissenschaft ins Auge fassen, in dem man die grundlegenden mathematischen Symmetrien findet."

172.Heisenberg, Encounters with Einstein, p. 130.

173.Heisenberg, Across the Frontiers, pp. 68-69; Heisenberg, Schritte über Grenzen, p. 150: "Daß sich an dieser Stelle die Möglichkeit eröffnet, in die zunächst unheimliche Leere und Ferne, in die uns Technik und Naturwissenschaft geführt haben, nicht zur mit dem Geist, sondern auch mit dem Herzen einzudringen..."

174.Ibid., p. 69; Heisenberg, Schritte über Grenzen, p. 150: "Sein kleiner Prinz, der für seinen Planeten sorgt, die Vulkane kehrt und die eine Rose begießt, lebt in jener Ferne, aber er lernt doch: 'On ne voit bien qu'avec le coeur, l'essentiel est invisible pour les yeux.'"

175.Ibid., p. 139; Heisenberg, Schritte über Grenzen, p. 224: "Denn die ganz großen Zusammenhänge werden in den Grundstrukturen, in den so sich manifestierenden platonischen Ideen sichtbar, und diese Ideen können, da sie von der dahinterliegenden Gesamtordnung Kunde geben, vielleicht auch von anderen Bereichen der menschlichen Psyche als nur von der Ratio aufgenommen werden, von Bereichen, die eben selbst wieder in unmittelbarer Beziehung zu jener Gesamtordnung und damit auch zur Welt der Werte stehen."

CHAPTER FOUR: ACTION

> In a recent discussion of this aspect of European history, Freyer has rightly referred to the old saying: 'Credo ut intellegam' - 'I believe so that I may understand.' In extending the application of this idea to the voyages of discovery, Freyer introduced an intermediate term: 'Credo, ut agam; ago, ut intellegam' - 'I believe so that I may act; I act so that I may understand.'[1]

That aspect of European history to which Heisenberg refers above is, in particular, the voyage made by Columbus into the West, believing as he did that the earth was round and small enough to be circumnavigated. His greatest achievement, says Heisenberg, was not in those two beliefs, which had occurred to others before him; rather, "His most remarkable feat was the decision to leave the known regions of the world and to sail westward, far beyond the point from which his provisions could have got him back home again."[2] In both art and science as well, as we have seen, it is impossible to advance in understanding without that hazardous leap forward, leaving behind the comfort of established style and doctrine. It is a leap of faith, which to Heisenberg means much more than simply holding this or that to be true; faith for the physicist is inextricably tied up with action: "If I have faith, it means that I have decided to do something and am willing to stake my life on it."[3] As Columbus did not think that it was possible to sail around the world in theory alone, but staked his whole existence on it, so too did the physicists press forward with their theories that seemed to

defy the unquestionable truth of Newtonian mechanics.

This last chapter, then, is an exploration of Heisenberg's understanding of faith, as it applies to the much larger voyage of life; he argues that scientists, in particular and because of their work, must use the understanding there arrived at, in connection with understanding from the other avenues, to act, and in that action, arrive at a truer understanding of ourselves and our relation to the central order. A focus will be made on his own deliberations and decisions to act in a certain way, that we can fully perceive the trust which religious understanding imparted to him, trust in the structures of existence, and the actions which must actualize these structures within, again, that they may be truly understood; if one may, as Heisenberg so often does, use a metaphor from the world of physics, then one could say that like the elementary particle which remains potentia until it comes into contact with the real world, then those structures of value within us are also potentia until like contact, that is, through deliberate ethical interplay with the world. There is no spiritual ascent, no understanding of one's relation to the central order, which has been explained as nothing more than the full realization of those inner structures, without an outer correspondence. Believe, act, understand - only then do the structures shine forth.

We must begin, having mentioned the 'real' world, with a final note on reality. When Heisenberg resurrects, in a

scientific context, the age-old question "of whether the Idea is more real than its material realization,"[4] he wonders if the problem is merely a question of discovering or defining the meaning of the term 'real.' For example, an Electron is not 'real' in a material sense - it is an idea, best described in terms of a probability function. When the wave function collapses, we no longer have an Electron, but an actualized particle which was modelled upon the idea. In Heisenberg's conviction that all EP's are manifestations of a basic structure represented as a mathematical symmetry, we again arrive at a reality distinct from the physical; the idea is the precondition for material existence, since the absence of the idea precludes its manifestations. Thus, "We may perhaps say with some exaggeration, that at the end of the journey we no longer find life or the world any longer, though we do find understanding and clarity concerning the Ideas whereby the world is made."[5] The Ideas, for Heisenberg, are the essentially real, since the world is simply an image of those Ideas.

Nonetheless, religion is the concern with the <u>human</u> relatedness to the central order, to the central reality, and thus must take into consideration <u>our</u> reality. As Heisenberg might say, it is only by working through our human reality, by making that voyage, that we may arrive at the highest reality. His own link with the central order came through a very real experience of music, and as it has been emphasized, there

would have been no ascension without that medium of music; in a larger sense, there is no upward movement of the mind without that interplay between the world and ourselves. At this point, it should be obvious that the tendency in Christianity and neo-Platonism to regard matter, or the world in general, as void of Ideas is not one with which Heisenberg agrees. Again, although it is true that the fundamental EP is an idea, there would be simply no legitimate notion of this idea were it not actualized by contact with the world. In a study of Pauli's philosophical outlook, shared in many respects by Heisenberg himself, he quotes the other's understanding of alchemy, especially as it can be related to the work both physicists did in their own field:

> ...since the intelligible was identical with the good, matter was identified with evil. But in the new science the world soul was finally replaced with the abstract mathematical laws of nature. Against this one-sidedly spiritualizing tendency the alchemistical philosophy, championed here by Fludd, represents a certain counterpose. In the alchemistic view [here, Pauli] 'there dwells in matter a spirit awaiting release. The alchemist in his laboratory is constantly involved in nature's course, in such wise that the real or supposed chemical reactions in the retort are mystically identified with the psychic processes in himself, and are called by the same names. The release of the substance by the man who transmutes it, which culminates in the production of the philosopher's stone, is seen by the alchemist, in light of the mystical correspondence of the macrocosmos and microcosmos, as identical with the saving transformation of the man by the work, which succeeds only "Deo concedente." '[6]

Clearly, not every day in the laboratory or at the accelerator produces this mystical correspondence, this immediate release of the spirit, although observation, or contact with the

world, is a release of the 'spirit of matter'; Heisenberg knew quite well that life is no series of joyful mystical experiences - life consists of everyday interplay, "doing one's bit as best as one possibly can," to paraphrase the physicist,[7] where "doing" is the key word. Life is necessarily characterized by action, by the reality of making decisions; as we mentioned much earlier, Heisenberg sees the philosophising of the ancient Greeks not as an exercise in intellect, but as the basis for action - what must I do? People will act, whether or not they have taken a particular idea or doctrine as the basis for life. To real-ize the entire spirit, to have it shine forth, one must act in the best possible manner.

In what may well be a Plotinian-influenced notion, Heisenberg seems to see the same guidelines working in nature, that is, nature, in reflecting the structures within us, seems to have the same goal, an understanding of its relationship to the central order. Plainly, this suggests a consciousness in nature, although Heisenberg would not attribute consciousness to nature in the same way it can be attributed to humanity; nonetheless, he is certain that we can speak of some sort of consciousness there, even though "the meaning of 'consciousness' ["Bewußtsein"] becomes wider and somewhat vaguer if we try to apply it outside the human realm."[8] Still, he seems to see that as the structures within ourselves must shine forth, that we may better understand them and thus

our relationship to the central order, so too must nature's structures shine forth. In fact, in this vein of releasing the natural spirit, Heisenberg speaks of "evolution", those points in nature where unique decisions were made to establish forms; for example, he calls nucleic acid the idea of the living being.[9] The various manifestations of this idea he speaks of as "accidents" ("Zufälle"), though accidental in the same way that the collapse of a wave function is the result of our arbitrary observation, remembering that the collapse is one in a definite range. In like manner, the manifestation of the idea of living being must occur within the structure of the idea: "these... models determine all subsequent developments. They are representative of the central order. And though accident does play an important part in the subsequent emergence and development of a profusion of structures, it may well be that accident, too, is somehow related to the central order."[10] Here, Heisenberg is, as always, thinking of the wider connection, that superstructure which lends meaning to the individual event. Thus, we return to the question of decision. It is only our decision to observe that manifests the idea of the particle, and in like manner nature can be said to 'intentionally' manifest some part of itself which fits into the entire structure, although Heisenberg insists on a more careful formulation of the word "intention" ("Absicht"), relating it to the previously-discussed idea of the possibility to be realized as influencing the course of

events. Interestingly, nature is very much like ourselves, for it must make those bold leaps, but in acting, finds that some of its creations do not fit into the order which it is unfolding: "selection then eliminates these 'natural experiments'. Only a few forms, which have proved themselves under the given circumstances, remain."[11] In traditional words, which, it must be admitted, Heisenberg does not use, the world soul must act to realize its relation to the central order, and sometimes discovers in action that some of its creations do not fit into that total order. One should not, it would seem, consider this a failure of any sorts; rather, knowing what does not fit into that superstructure only leads to the understanding of what might.

Fascinating as this line of thought may be, the issue here is with the human relation to the central order, and the above was simply used as an analogy of human realization through action. As nature seems to be, so is Heisenberg concerned with action, that is, the best possible action: hence, "ethics [is] the presupposition of life. For every day we must meet decisions, and we must know or at least have an idea of the values which govern our conduct."[12] The requirement that we possess some perception of the values by which we are guided is not an idle one; the 'utility cult' of modernity, discussed above, illustrated the danger of a lack thereof. Although Heisenberg is clear that utility as such is not a value, it was seen that way by many. Nonetheless, what

has become very apparent, at least in this study, is that science cannot give the necessary values, and neither can it exist fruitfully without them; remembering the perils of a science broken away from the central order, science should aim at supporting those values: "The correctness of proven scientific results cannot sensibly be doubted by religious thinkers, and vice versa, the ethical demands which proceed from the heart of religious thinking should not be dissolved by extreme rational arguments from the sphere of science."[13] Thus, when searching for the ethical framework in which to base one's action, Heisenberg believes that one must stay with those values uncovered by the religious traditions: "if we are honest, we should advise [the young] to cling to the old standards of value, which have been conserved in the great religions; for the time has not yet come for the writing of a new canon. A rationalistic analysis of social relationships is certainly not adequate for that."[14]

Of course, Heisenberg is aware that different religious traditions, though all are necessary to the full understanding of the human relationship to the central order, may have unique frameworks, since they may be based on complementary truths, "and this fact should be acknowledged with regard to those groups of people whose basis is different than our own."[15] Yet, it may not be wrong to suggest that Heisenberg believes the most important structures, those that guide our actions, have been realized by all the great traditions, and

he certainly takes insights from each. Be that as it may, he ultimately remains within his own Christian tradition, especially as it enfolded the concepts of antiquity, which together give to the West "a judgement in which spiritual values are prized higher than material ones. It is precisely in Greek thought, and in all the traces of it that we have inherited [through Christianity], that the pre-eminence of the spirit emerges."[16] Actually, it is not even a matter of choice for the physicist: he remains within the tradition for the simple reason that he is unavoidably rooted in it, by birth, country, and education. The precepts in that tradition are what might even be called the 'natural laws' of the West: "If we ask Western man what is good and what is evil, what is worth striving for and what has to be rejected, we shall find time and again that his answers reflect the ethical norms of Christianity even when he has long since lost touch with Christian images and parables."[17]

How inescapable these roots are can "scarcely be better described" than it is by Romano Guardini in his work on the characters in Dostoevski's novels. Heisenberg observes:

> The life of the characters is filled at every moment by the struggle for religious truth and is somehow imbued with the spirit of Christianity, and hence it does not matter so much whether these people are victorious or defeated in the struggle for goodness. Even the greatest villains among them still know what is good and what bad, measuring their deeds by the guiding ideals that the Christian faith has given them. Here also lapses the familiar objections to the Christian religion, that men in the Christian world have behaved just as dreadfully as those outside it. That is unfortunately true, no doubt, but these men preserve in themselves a clear power of

> distinguishing good from bad; and only where this is still present does the hope of improvement remain.[18]

The West has not lost entirely that power of distinguishing good from bad, but the power has faded. Clearly, science's insistence that it cannot provide different values - or any values - is a great step towards this re-visioning, and art must do its part as well (as Dostoevsky obviously tried to do). Only through a recovery of those spiritual values can we recover from the spiritual catastrophe of modernity, and discover the framework in which our actions, and lives, have significance: "Where no guiding ideals are left to point the way, the scale of value disappears and with it the meaning of our deeds and sufferings, and at the end can lie only negation and despair."[19]

Regarding these standards of value as forms of coercion is the height of folly to Heisenberg: "freedom in the decisions of life is likewise possible only through adherence to moral norms, and anyone who thinks to disdain these as a form of coercion would merely be replacing freedom by lack of principle."[20] He understands two aspects to freedom, the freedom from, and the freedom to: "In the case of mental freedom, it is a matter, on the one hand, of freedom from prejudices, from dogmatic ties, from suggestive influences, from an imposed point of view; and on the other of being able to think new thoughts, to look at known facts with fresh eyes, to follow the thoughts of others, even if they at first do not illuminate, and to go beyond them."[21] In this case, the

freedom is one to spiritual realization. He points here to the lesson of science, that freedom is possible only through the acknowledgement of laws; for example, the freedom to fly depends on the acknowledgement of the laws of aerodynamics. But this is not a new awareness - it was said long ago that "the truth shall make you free." Science and religion agree again when they state that freedom is difficult:

> to perceive new connections amid the inexorable laws of nature, to explore new possibilities, to think in unaccustomed ways, can be achieved only with the utmost effort. But anyone who finds it too difficult should not be led astray into simply ignoring the existing laws. Nothing whatever would come of that. He will then be well advised, however, to stay within the framework of what already exists, and to carry out his work with care; that is always worth while.[22]

The beauty of Heisenberg's thought, it would seem, is found in his conviction that the overarching superstructure is carefully ordered at every point, and thus, as was suggested a moment ago, there exist laws in the realm of value as much as there are in nature. Hence, when he is ostensibly discussing the scientific world, one is often quite sure that those same words can be applied to the spiritual. Of the above there is no doubt. Ethically speaking, the freedom to perceive new connections, explore new possibilities, and to think in unaccustomed ways, is a very difficult thing to achieve. In science, the realization of the new connections took faith, patience, courage, and adherence to law (recall that Newtonian physics are indispensable to quantum physics). In the face of glaring injustice, some will be tempted to leave behind those

qualities in order to quickly remedy that injustice, and this is a disastrous course of action. For example, Heisenberg could sympathize with the genuine concerns of a Hitler Youth Leader, that Germany was in a bad state after WWI, and he declared his full support to any movement that tried to right the existing wrongs; however, he refused to agree that the methods used by the various movements to achieve new possibilities would build a better Germany. That the Youth Leader was himself aghast at those methods - "I myself find these outrages just as repulsive as you do" - made little difference to Heisenberg:

> I won't, of course, deny that you personally have every intention of getting [to a better Germany]; but on the whole all we can say with certainty is that the old Germany is being destroyed, and that injustices flourish all around us - [that your movement will rid itself of the evil element] is nothing but wishful thinking. If you would simply try to remedy what injustices there are, I would be with you all the way. But what is happening is something quite different.[23]

As in art, as in science, so an ethical revolution is possible only through a strict adherence to, in this case, moral law: "Think of that great revolution two thousand years ago, whose maker said: 'Think not that I am come to destroy the law...but to fulfil it.'"[24] Of course, the analogy which is constantly at Heisenberg's lips is that of Planck's discovery of the quantum. Absolutely the last thing that conservative physicist wanted was the overthrow of classical physics, which he thought the cornerstone of science; yet it was only by working through classical physics as assiduously as he could that an

innovation forced itself upon him. Heisenberg adds that it is only crazed fanatics in science who would try to overthrow everything, for example, by asserting that a perpetual motion machine could be built; all such attempts are completely abortive. In the end, "what matters is to confine oneself to a single, important objective and to change as little of the rest as possible. The small part we have to change may well have so great a transforming force that it may affect all forms of life without further effort on our part."[25]

Given that Heisenberg was fully aware that the old Germany was being ruined, one might (as so many have) question his decision to remain there during those terrible years. By the late twenties, on the scientific front, Einstein's theories were being attacked on the basis of race, and a move was being made to discredit the new physics through evocation of the principles of classical. An "aryan physics" sprung up in opposition to the new physics, and many physicists felt emigration the only answer to this anti-semitism, experienced in many other aspects of their life besides the scientific; the ranks included Einstein, Max Born, James Franck, Felix Bloch, and Hans Bethe, to name a few.[26] This "aryan physics" alone, knowing Heisenberg's dedication to truth in science, must have particularly struck him as sheer, and dangerous, lunacy. Few physicists were left in Germany teaching the new physics. In his own university, "political interference ...became more and more intolerable. One of my faculty

colleagues, the mathematician Levy, who, by law, should have enjoyed immunity because of his distinguished war record, was suddenly relieved of his post. The indignation of some of the younger faculty members of the staff...was so great that we thought of tendering our resignations and of persuading other colleagues to follow suit."[27] But, Heisenberg says, before taking this grave step, he decided to discuss the entire matter with Max Planck. Some time will be spent here reproducing and considering this conversation, since Heisenberg understands this discussion as one of the most significant in his life, and his decision to remain in Germany one of his most momentous decisions, making science very much a matter of 'life and death' (needless to say, Planck was not suggesting action to Heisenberg thoughtlessly: he, too, remained, and had his life shattered by war).

Planck's real anguish over the situation, even as early as 1933, was apparent to Heisenberg: "Planck seemed to have grown a good many years older since our last meeting. His finely chiselled face had developed deep creases, his smile seemed tortured, and he was looking terribly tired." Heisenberg remembers Planck beginning like this:

> 'You have come to get my advice on political questions,' he said right off, 'but I am afraid I can no longer advice you. I see no hope of stopping the catastrophe that is about to engulf all our universities, indeed our whole country. Before you tell me about Leipzig - and believe me, things couldn't be worse than they are here in Berlin - I would like to apprise you of my conversation with Hitler a few days ago. I had hoped to convince him that he was doing enormous damage to the German universities, and particularly to physical

> research, by expelling our Jewish colleagues; to show him how utterly senseless and utterly immoral it was to victimize men who had always thought of themselves as Germans, and who had offered up their lives for Germany like everyone else. But I failed to make myself understood - or, worse, there is simply no language in which one can talk to such men. He has lost all contact with reality...A man like that can only lead Germany into disaster.[28]

The partial order, as mentioned in connection with Goethe's foreboding of the Machine, although partial, is a dynamic order. All orders have that dynamic 'glow and sparkle', whether or not they are appropriately situated in the central order. Thus, when Heisenberg mentions to Planck that he and his fellow colleagues planned to resign, Planck answers that such efforts would be completely ineffectual at that point, both in practical terms, e.g., the public would either hear nothing of it in the papers, or interpreted there as an unpatriotic move; in terms of a 'natural law',

> You simply cannot stop a landslide once it has started. How many people it will destroy, how many human lives it will swallow up, is a matter of natural law, even if we ourselves cannot predict its precise course. Hitler, too, can no longer determine the subsequent course of events; he is a man driven by his obsessions and not someone in the driver's seat. He cannot tell whether the forces he has unleashed will raise him up or smash him to pieces.[29]

Planck sees only three options left to Heisenberg. In the face of the unavoidable catastrophe ahead, the first option, resignation, would have no meaning but to ruin Heisenberg's career -"I know you are prepared to pay the price"[30] [whether Planck actually said this, or whether Heisenberg is later clarifying his position at the time, does not matter; the

present writer is fully convinced that no matter who spoke it, it was true.] There is nothing one can do during a landslide but wait for its end, and only then is one able to discover what one can do: "your actions will only begin to matter again after the end of the present catastrophic phase. It is to the future that all of us must look now."[31] The second option, a very real one for Heisenberg, since he had received offers from abroad, was emigration. Planck counsels Heisenberg to think carefully about this:

> ...abroad you will be one of countless emigrants in need of a job, and who knows but that you would deprive another, in much greater need than yourself? No doubt, you would be able to work in peace, you would be out of danger, and after the catastrophe you could always return to Germany - with a clear conscience and the happy knowledge that you never compromised with Germany's gravedigger. But before that happens many years will have passed; you will have changed and so will the people of Germany, and I don't know whether you will be able to adapt yourself to the new circumstances, or how much you will achieve in this changed world.[32]

Finally, Planck, and no doubt Heisenberg, reaches the final option to be taken into account, remaining in Germany and doing one's job, by far the most difficult option, and truly one that requires the most faith, in the sense discussed above:

> If you do not resign and stay on, you will have a task of quite a different kind. You cannot stop the catastrophe, and in order to survive you will be forced to make compromise after compromise. But you can try to band together with others and form islands of constancy. You can gather young people around you, teach them to become good scientists and thus help to preserve the old values.[33]

Planck cautions Heisenberg that not all such islands ("Inseln

des Bestandes") will survive the catastrophe, but he is certain that even if small groups of "talented and right-minded young people" can be guided through the terrible times ahead of them, then those who elected to stay will have accomplished a great deal to ensure Germany's resuscitation after the end: "For such groups can constitute so many seed crystals from which new forms of life can arise."[34] It is not insignificant to note that although Planck is thinking first and foremost of scientific research in Germany, he feels that those islands of constancy will enclose much more than simply scientific research; true science taught will also be the vehicle for right living. This is true, he says, of any field of endeavour. Hence, Planck is convinced that anyone who is not absolutely forced for racial or other reasons to emigrate has an obligation to stay on and "lay the foundations for a better life once the present nightmare is over."

But Planck is quick to warn Heisenberg that such an undertaking will be both difficult and dangerous, and that the compromises which he, or anyone else, is forced to make will later, and rightly, be held against him. Of course, Planck cannot blame those who decide that life in Germany is intolerable, those who decide they cannot remain while injustices they have no power to prevent are committed all around them. Yet, as Heisenberg might say, Planck is forced to confront 'natural fact':

> But in the ghastly situation in which Germany now finds herself, no one can act decently. Every decision we make

> involves us in injustices of one kind or another. In the final analysis, all of us are left to our own devices. There is no sense in giving advice or accepting it. Hence I can only say this to you: No matter what you do, there is little hope that you can prevent minor disasters until this major disaster is over. But please think of the time that will follow the end.[35]

It might not be too far off to speculate that Planck embodies for Heisenberg the Germany that he loved so well, and his plea to consider remaining a plea from the heart of that old Germany, racked with disease, desperately needing someone to stay and look after her. It was not an easy decision for Heisenberg, and "I almost envied those of my friends whose life in Germany had been made so impossible that they simply had to leave. They had been the victims of injustice and would have to suffer great material hardships, but at least they had been spared the agonizing choice of whether or not to stay on."[36] On the one hand, emigration seemed to him like a betrayal to the people of his country: "if you cut off your roots and moved, might you not be simply leaving the field to those madmen, those spiritually unhinged creatures whose demented plans were driving Germany headlong into disaster?"[37] Furthermore, he had the example before him of the Soviet Union, where the chosen basis of thinking, dialectical materialism, impeded to a great extent scientific development and understanding: "official Soviet philosophy has had a hard time coming to terms with relativity and quantum theory; there have been severe conflicts of opinion in the matter of cosmology."[38] Who was to say that Germany would

escape such a situation, particularly in the face of this "aryan physics"? For Heisenberg, the truth of science was simply too important for it to be left in uncertain hands.

On the other hand, Planck had insisted that staying would involve compromise, and unjust action on one's part. In an attempt to understand what Planck meant by this, Heisenberg arrives at a thought experiment: a dictatorial government, imprisoning ten of its most important opponents, wishes to kill at least one, although wanting this murder justified in the eyes of the world. If a famous jurist can produce and sign a legal document justifying the murder, then the other nine will be spared. If he refuses to do this, all ten will be killed. The question for Heisenberg is whether a clear conscience is worth more than the lives of the other nine. "Thinking along these lines, I remembered a conversation with Niels Bohr, during which he referred to the fact that justice and love were complementary concepts."[39] That is, Heisenberg realizes that though both are crucial concepts of our action, they are mutually exclusive. Quite likely it was in facing this decision that he fully realized the depth of the insight of complementarity: justice and love were both necessary to the understanding of the central order, but we could often only understand them, through action, separately. Only when guided by justice does one become deeply aware of the need for love, and vice versa. For example, justice would demand that the jurist withhold his signature, "the more so as the

political consequences of his signing might be as such to destroy many more innocent people than the nine friends;" justice would demand that Heisenberg leave Germany. Love would demand that he listen to "the cry of help sent up by the desperate families of the nine friends;"[40] love would demand that he remain in Germany, to do what he could for his people and his country. Yet, think all he wanted to, Heisenberg was aware that a decision must be made; he could not forever "go on playing such absurd mental games,"[41] as if it were a mathematical question he was toying with. It was a crucial matter which had to be decided, one which needed a moral ground, faith, and that bold leap forward. In the end, the physicist decides to be guided by the law of love. Of course, how infinitely more preferable to feel both loving and just! But he could not abandon Germany, so perfect and pure justice must be sacrificed. Planck, he thought, was right in his exhortation to think of the time after the catastrophe:

> We would have to form islands, gather young people round us and help them to live through it all, to build a new and better world after the holocaust. And this was bound to involve compromises, for which we would rightly be held to account - or perhaps even worse. But at least it was a worthwhile job. The world outside did not need us; there were others who could fulfil the tasks set there much better than we could.[42]

Perhaps Heisenberg did not realize then the further sacrifices he would have to make, and suffering that he would have to bear, though he would be the first to insist that his suffering was negligible compared to that of many others. He certainly felt his duty a crucial one, and it is not

insignificant that Planck and Heisenberg both believe that teaching the young to become good scientists was an effective way to preserve the old values, values necessary to an authentic foundation for a reconstructed Germany; time and again it has been emphasized that Heisenberg understood science as very much an approach to religious understanding, that relation to the central order without which humanity would perish. It was to this single, important objective that Heisenberg was convinced he must confine himself; furthermore, in this case, not only was it imprudent to attempt changes in the larger realm, it was, as Planck said, impossible.

There is little doubt that he did suffer through this decision, and he characterizes the immediate prewar years "as a period of unspeakable loneliness,"[43] both professionally and personally. By 1937, many of his friends had departed the country. War seemed imminent, and in Germany itself "this situation was aggravated by the isolation of the individual."[44] Communication became increasingly difficult - one spoke one's mind to only especially close friends, or spoke a language which hid more than revealed. Heisenberg reports that he felt the atmosphere of distrust "unbearable", "and the certainty that it was all bound to lead to the total destruction of Germany only drove home to me the severity of the task I had set myself on returning from Max Planck."[45] Yet, he was able to survive the horrible atmosphere, sustained, it would appear, by that faith in the central

order. Some light is shed on this by a very interesting conversation after the war, where Heisenberg spoke with Konrad Adenauer, who had undergone severe hardship in a Gestapo prison. Although Heisenberg disagreed with the post-war, pro-atom bomb course charted by Adenauer, he was unwilling to completely discredit the compass by which Adenauer lived, and notes that in the very worst times, that compass had stood him in good stead:

> The Catholic faith contains a good dose of Eastern wisdom, and it was precisely this wisdom from which Adenauer drew strength in times of difficulty. I remember a conversation about our several experiences in P.O.W. camps. Adenauer had been incarcerated in a Gestapo prison with starvation rations, while I myself had had a relatively pleasant time in England, and so I asked him one day whether he had suffered a great deal. 'Well,' he said, 'when you are locked up in a small cell for days, weeks, months, and are never disturbed by telephone calls and visitors, you can think back at leisure on the past and reflect quietly on what may still be in store for you, and that is really a quite nice thing to do.'[46]

It is very likely that Heisenberg also drew strength from this wisdom during the mental solitude - the "inner exile"[47] - of his own war experience, a solitude which began when he made that decision to stay in Germany. He could go on only knowing that there was a different past, and a different future. For example, walking through a devastated Berlin after an air raid, "we had time for a fairly long conversation, not about Germany's present situation - that was only too obvious all around us - but about our hopes and plans for the post-war period,"[48] the re-blossoming of true, and international, scientific research. At this late point in the war, Heisenberg

possesses confidence that Germany would find her way back to the true reality; this was discussed earlier. But this confidence was not so clear in the beginning; he had to earn it. He speaks of the Stations of the Cross that must be endured by the world if it is to recover the 'certainty in the strivings of the heart';[49] clearly, Heisenberg had to endure personal Stations to arrive at the same certainty, which is a certainty not only of direction, but certainty through action aimed at that direction. Hence, although having made his decision, the time soon after that decision was one marked with uncertainty, that is, there were times of complete despair, when Heisenberg could not look past the utter loneliness which engulfed him.

During one exercise in humiliation that Planck had warned him to expect, where Heisenberg was forced to sell "Winter Aid" flags in the centre of Leipzig, he recalls: "I was in a state of complete despair as I rattled my box, not because the show of subordination I had been forced to make bothered me in itself, but simply because of the utter senselessness and hopelessness of what I was doing and of what was happening all around me."[50] A "strange and disturbing mental state" suddenly came over him, and the buildings and people around him began to lose their reality, as if everything had already been destroyed, with only phantomlike images remaining. Yet, "behind these ghostly figures and the gray sky, I sensed a strong brightness. I noticed that several people stepped up to

me with unusual cordiality, and gave me their 'Winter Aid' contributions with looks that brought me out of my reveries and, for a moment, bound me closely to them."[51] Heisenberg seems to simply be saying that, for one moment, the central order shone through, and gave him strength. Nonetheless, the brightness was short-lived, and "then I was far away again, and began to fear that so much loneliness might well prove more than I could bear."[52] Invited that evening to a musical gathering, Heisenberg, who had found his link to the central order through music, and for whom dialogue with others was essential, conveys in a sentence his immense suffering: "I was afraid of the music and of meeting new people." Yet, one of the guests, his future wife, "managed to reach across to me even during our first conversation, and drew me back from the far reaches to which I had withdrawn. I felt I was on solid ground once again, and this sensation grew stronger as I continued our conversation while playing the trio."[53] Heisenberg connects the two incidents, and it seems fair to state that the 'strong brightness', in whatever form, gave him that certainty, sustained him through the trials of his decision, even through the trials of compromise.

Heisenberg did compromise, as Planck again expected he would have to, though the nature of his compromises seemed to be in connection with upholding of the truth and value of science. In one instance, if it is understood correctly, Heisenberg demanded the restoration of his "honor" after being

accused as a "Jew lover" and "Jewish pawn" by one of the leaders of the "aryan physics", knowing that his teaching position hung in the balance, and consequently, his single, important objective. During the following investigation, Heisenberg was "interrogated", although he was, again, the first to admit that he had an easier time of it than most. In the end, his "honor" was restored, and he was allowed to continue teaching the new physics to his students. His wife gives some vital insight into especially this compromise:

> An idle lifting of the hand meant nothing to him; he thought it ridiculous to get upset about a Heil Hitler under an official or semi-official letter. He made compromises when it was a matter of assuring something he thought to be important, especially if it seemed necessary to protect himself from blatant threats to his existence. He could only maintain his inner composure, menaced by the deep horror called forth in him through the crimes of the Nazis and the war, by contrasting it with the clear world of science in which he saw the eternal verities that would outlast the terror of those times. In this area, compromise was not possible. His bravery was of an intellectual nature, and to him the compromises were like the ripples on the surface of an ocean, though it could easily swallow you [emphasis added].[54]

This decision to stay and form the islands of constancy, to try to teach true science and all that followed from such teaching, lost him the respect of a good many of his friends, and history has often judged him harshly.[55] A blow that truly affected Heisenberg was the shattering of the deep father-son relationship he enjoyed with Niels Bohr, a break never, it would seem, to be completely healed; this grieved Heisenberg tremendously. Of course, the break occurred when Heisenberg tried, in that language of non-communication

("since I had reason to believe that Niels was being watched by German agents"[56]), to tell Bohr that the German physicists were trying to thwart the end to which their talents had been directed, that is, the construction of the atom bomb. Heisenberg ventured to suggest that perhaps all physicists should 'advise' their respective governments that either too great a technical effort was needed to accomplish this, or that it <u>was</u> possible to build a bomb, and that all efforts should be directed there (since Heisenberg did not believe that construction of the bomb could be completed by the end of the war). Niels, horrified at the mere mention of an atom bomb, did not follow the rest of Heisenberg's remarks;

> Perhaps he was also too filled with justifiable bitterness at the brutal occupation of his country by German troops to entertain any hopes of international understanding among physicists. I found it most painful to see how complete was the isolation to which our policy had brought us Germans, and to realize how war can cut into even the most long-standing friendships, at least for a time.[57]

As it happens, not only did this incident destroy that bond between Heisenberg and Bohr, in the larger scheme it seems to have had the effect of intensifying work on the atom bomb: Bohr informed the Americans that the Germans knew how to build atom bombs, that they were constructing one, and that Heisenberg was the leader of the project. The history of the Manhattan Project is well enough known that it need not be examined.

The question of blame for the construction of the atom bomb which was dropped on Hiroshima is a difficult one for

Heisenberg. Heisenberg holds that physics merely discovered atomic fission; the bomb was invented. As discussed earlier, technology is not inherently evil: ultimately, it is value-neutral, and is used for ends which are not extracted from science and technology itself. Actually, it might be better stated that 'technological ability' is ultimately value-neutral, since an atom bomb, created by scientists and technologists, is in fact inherently evil, since it is intended to inflict death and destruction; an atom bomb is not valueless, as poison gas and machine guns are not. One might go so far as to suggest that the technology of the modern world, developing out of the notion that "knowledge is power," is intrinsically slanted in the direction of domination and control, both of nature and people; if this is so, then the technology of the modern West cannot claim to be value-neutral. Yet, it is an ancient recognition that it is in the nature of humanity to build and create;[58] it is in choosing what to create that the question of value enters. Hence, in his judgement of technology as value-neutral, I would argue that Heisenberg is in fact referring to that basic technological ability of humanity, the natural talent for material invention and innovation. Again, the question of value enters when a decision is made to utilize that talent to a particular end.

In this case, the decision to create an atom bomb, Heisenberg found it difficult to imagine that the scientists

whom he had known so well had thrown their full weight behind such a project; however, he understood that many might have felt that "a Nazi victory with the atom bomb must have seemed so ghastly a threat that anything seemed justified to stop it, even an atom bomb of one's own."[59] Yet, he wonders if those physicists did not pose to themselves the question of whether, though a Nazi victory may well have been a terrible thing, the invention and use of an atom bomb be even worse in the long run? Nevertheless, Heisenberg refuses to lay full responsibility of the invention on those involved in the American project; it was, he concedes, a difficult decision, and "I simply feel that in this particular respect we happened to be luckier than our friends across the Atlantic."[60] Furthermore, he prefers to think that the decision to use the bomb was taken out of their hands: "After the end of the war in Europe, probably many American physicists advised against the use of this terrible weapon, but by that time they no longer had a decisive say."[61]

His friend von Weizsäcker reminds him that, in this context, if the scientist wants genuinely to act for the best, and not just leave it at "noble thoughts", the scientist will "'probably have to play a more deliberate part in public life, try to have a greater say in public affairs.'"[62] Heisenberg is in full agreement, and thus, what Heisenberg wanted from the government after the war was more than financial aid for the scientific research he had helped to preserve; "I was

equally anxious to ensure for science a wider degree of influence over government decisions."[63] The example of the American bomb underlined the necessity of giving scientists and technologists some control over their research and technology. Additionally, Heisenberg realized during the early years of reconstruction that "It was quite obvious that scientific progress and the resulting technological developments would have an extraordinarily important effect not only on the reconstruction of our own cities and industries, but also on the social structure of Europe as a whole."[64] Those responsible for the scientific and technological advances should be allowed a greater say in further direction and utilization; furthermore, these people must come to the understanding that it is their obligation to make themselves heard: in the clearest instance, "obviously it is the duty of scientists to inform their governments in detail about the unprecedented destruction that would follow from a war with thermonuclear weapons."[65] These wider aims of concerned scientists will not be taken seriously if the scientists are concerned merely in theory:

> ...the hearts of men will be sooner won by setting exalted goals and showing a real willingness to take part in the common creation of this extraordinary modern world. For only those who take part can also influence the course of that world in the direction they think desirable.[66]

In this, he is likewise convinced that this political involvement will entail that bold leap for the individual scientist: "he will eventually have to face the responsibility

for decisions of enormous weight which go far beyond the small circle of research and university work to which he was wont."[67] On the other hand, retreat from this enormous responsibility is not ethically acceptable; he who elects to remain with the quiet life of a scientist "will still remain responsible for wrong decisions which he could possibly have prevented had he not preferred [that] quiet life."[68] Although one might argue that the isolated scientist was simply concentrating on his one, important objective, Heisenberg would probably argue that that objective must be understood in the larger framework; if the larger framework is not understood and established, then his work is of little importance. Hence the absolute need for that interaction between the scientific and political community.

Furthermore, Heisenberg is convinced that scientists can add much to the political process, and seems to hold with von Weizsäcker, that although scientists would not necessarily make better political decisions than the politicians themselves, "their scientific work has taught them to be objective and factual, and what is more important, to keep the wider context in view. Hence they may introduce a measure of logical precision into politics, of greater objectivity and of respect for the facts."[69] If anything, scientists have learned through their work that their task requires care and sober judgement: "[the scientist] cannot let himself be dazzled by prejudices and illusions, he must renounce all the

simplifications that are often so dangerous in political life, if he is really to be equal to the responsibility entrusted to him and to discharge it with success."[70] Heisenberg is seeking a diffusion of this care and sobriety throughout society in general, and through politics in particular, as he additionally seeks the diffusion of science's greatest insight - the interconnectedness of the world; for example, chemistry, physics and biology were all once considered separate fields, a consideration that has now gone by the board. Although it is true that this is grasped only by the narrow circle of those working in the fields, "even from this circle it is possible for influences to spread into human thought generally."[71] In the political realm, and "in regard to the great political dangers of our age," Heisenberg hopes for a spread of that feeling expressed by a Russian physicist at an international conference:

> We are travelling on a space ship that has already been circling the sun for untold ages, and is voyaging in company with that great star through infinite space. Whence and whither we do not know; but we are travelling together on the same ship.[72]

Yet, for all Heisenberg's endeavors in this area, to which he devoted a great deal of time and energy, his plans came to nothing, and he could not convince that all were travelling together: "I failed to win the university and educational authorities over to the new ideas."[73] Although he was encouraged a few years later, when it did appear as if the contributions of Germany's physicists and engineers were

being actively sought in the political decisions concerning the opening of a research atomic reactor connected to industry (and consequently, economics), his high hopes were soon disappointed: Heisenberg was convinced that a completely political decision was made to geographically separate the scientific institute and that practical research centre, which Heisenberg was worried might end a close collaboration between the two centres, a collaboration devoted to the peaceful uses of atomic energy. "I was also disturbed to find that for those who had to make the most important decisions the boundaries between peaceful and military applications, no less than between atomic technology and fundamental atomic research, were extremely fluid."[74] When the issue of atomic rearmament reached a crisis point, a good number of physicists, including Heisenberg, applied a great deal of pressure to the Federal Republic's government, issuing a manifesto which had as its aim "definite objectives, capable of being implemented under the current circumstances."[75] The manifesto had a powerful effect on the German people, as well as on many others around the world, and the Federal Republic politicians were, unsurprisingly, not at all happy with this 'interference'. Heisenberg took great pleasure in Adenauer's realization that the manifesto could not be swept under the rug, that it seemed to have struck a vital chord in people. The physicist appears to attribute the manifesto's success to its honest practicability; certainly, it is true that situations in which

people feel impotent may well unfold without a murmur of dissent. Hence, Heisenberg considered this manifesto much more meaningful than the joint declaration of physicists opposed to the atom bomb which he had signed earlier:

> To state publicly that you are for peace and against the atom bomb is, after all, nothing but silly chatter. Every human being in his right mind must obviously be for peace and against the bomb, and he does not need us scientists to tell him so. The government will simply include all such protests into their calculations. They will declare themselves wholly in favour of peace and against the atom bomb, and simply add the subsidiary clause that, of course, they mean the kind of peace that is favorable to, and honorable for, our own people, and that they are, meanwhile, doing their utmost to defend us from the reprehensible atom bombs of others. And so we are not a single step forward.[76]

Without a precise statement of the conditions under which peace is to be favored, one should, says Heisenberg, suspect that the peace favored is a self-interested one, that is, the "kind of peace in which [those offering it] thrive best."[77] As he learned from his decision to remain in Germany, Heisenberg realizes, again, that some sacrifices would have to be made if the intention is a genuine one: "Any honest declaration of peace must be an enumeration of the sacrifices one is prepared to make for its preservation."[78]

Of course, what Heisenberg asks from the political realm he also asks from the scientific. Action is not easy, and the sacrifice that comes with right action is often difficult to bear. For example, scientists must, as well as becoming politically active when they might well prefer to remain in their own scientific world, learn sacrifice in their own work.

The physicists who signed the above manifesto "solemnly refused every form of participation in any atomic rearmament program," although no one would deny that the problem of technological exploitation of atomic energy was a fascinating one. Even Heisenberg, beginning work on the project during the war, admitted that they were "working in a very interesting branch of physics, and if we were at peace and nothing else were involved, we should probably be very happy to work at a project of such wide scope."[79] However, as stated above, physicists must look at the wider connections, since science has no value outside of the larger structure, and here lies a complication: it can be very tempting to ignore that wider structure to solve a problem in which one has personal interest. Heisenberg recalls urging that a plan to test the first hydrogen bomb in the Pacific be aborted, in view of the biological and political consequences; the physicist Fermi simply replied, "'But it is such a beautiful experiment.'"[80] Heisenberg warns that this very vision of the dazzling parts may obscure the vision of the whole. But Heisenberg is not asking that the scientist sacrifice intellectual honesty, since "the scientist's first claim will always be [that] intellectual honesty;"[81] rather, with a vision directed to the broader context, there will be areas that the scientist will consider carefully before entering. On the practical level, merely because we possess the ability to do something, it does not necessarily follow that we should do it; the

broader connections must always be kept in mind. Science for science's sake, art for art's sake, knowledge for knowledge's sake: each is more than meaningless - it is dangerous, more so when one small part adversely affects the larger whole. Adrift, as Goethe would say, without guidance, and at the mercy of the devil. Only with the compass of the central order, a compass that demands sacrifice from science if it is to find its place in that overarching superstructure, can action with respect to science have any meaning. Heisenberg, then, asks only that "the individual tackling a scientific or technical task, however important, must nevertheless try to think of the broader issues. And, indeed, if he did not, why did he exert himself in the first place? Moreover, he will arrive at the correct answers more readily, the more he bears the wider connections in mind."[82]

Although religious understanding is a communal effort, it <u>does</u> begin with the individual. Although the separation into subject/object may be a useful tool in some aspects of science, one cannot separate oneself from life; the individual can never stand back and state that he refuses to interact. He does. It is, really, a person designing a bomb, and a person measuring the stars, and a person setting up an experiment. It is crucial to remember that science is not a thing in itself: it is made by people, 'a self-evident fact that is far too often forgotten.' Hence, it is the individual scientists who must act first to achieve an understanding of their own

relation to the central order, which is the obligation of all humanity; as well, they must act to achieve an understanding of the appropriate place of science among the avenues of that self-discovery. The first is the prerequisite of the second; without at least a personal and individual hint of that relation, scientists will never truly understand the work that they do, nor how it fits in the wide scheme of things. Thus far, this has been discussed in connection with those mathematical and scientific structures within that find their correspondence without, particularly if the vision is directed to the central order. But Heisenberg means something, perhaps less 'exciting', but much more than this. Science is a springboard, but one must have an idea of what one is springboarding into. Any true understanding in the individual begins with "the very humdrum counsel that everyone ought to do his work as conscientiously and decently as he can, hoping that his example may produce some good in the end."[83] That is, everyday life and work must fall within the standards of value preserved by the great religions. Love, justice, kindness, compassion - one may believe theoretically in their merit, but until one has acted again and again lovingly, justly, kindly, compassionately, believing in them even if at times they appear meaningless, one will never discover their deepest truth. Having discovered their truth, or even continuing to try in the belief that they are true - in both cases the action must continue - has an effect not only on the

individual, but a diffusing effect on those around him:

> It will be a matter of reanimating in daily life the values grounded in the spiritual pattern of the community, of endowing them with such brilliance that the life of the individual is again automatically directed toward them.[84]

The scientist, as a human, must follow the laws of value as much as he must follow the laws of nature if he is to grow spiritually; all people must grow in this manner, but it would seem that Heisenberg asks more of his particular community, since in their capacity as scientists, they now have a very difficult task, and an immense responsibility. Especially today, their scientific understanding cannot be separated from their ethical understanding. And if scientists must endure sacrifice, suffering, and compromise in playing their very real role in the re-spiritualization of the modern world, then the strong foundation in which Heisenberg believes the scientists must be grounded will give them the courage, fortitude and trust to continue.

If this sounds incredibly idealistic on Heisenberg's part, then it must be remembered that he asks no more of the scientific community than he himself has given. In fact, it seems likely that he would not ask it if he himself had not experienced the trials of remaining in Germany during the war. Believe, act, understand - few people have taken this as seriously as did Heisenberg. The very fact that the physicist travelled to America and returned to Germany even <u>after</u> he had undergone some of his worst ordeals, i.e. his too-clear

realization that Germany was well on the way to her descent, and that sheer and utter loneliness which nearly paralysed him spiritually, illustrates that deep trust in the central order, that his action - that his love - was not meaningless in the face of chaos. He may have discovered in his youth his link to the central order, that the towering structures in his soul were images of the structures of the most central order, but he discovered later that the central order demanded a closer link, that the central order had a plan, and that Heisenberg had his part to play in it. Obviously, God did not meet Heisenberg on a mountain to inform him. But the central order was not silent: it spoke through art, science, religion, and the soul - setting out the superstructure, and asking that it be adhered to, even if runs counter to one's personal wishes.

Of course, there is a great deal that humanity has not yet understood, and thus an infinite part of that structure is still hidden from us. But, as we have seen in art, and in science, understanding comes only through action, through a continued interplay between oneself and the world; only then are the existing structures understood, and the new structures unfolded. In this case, believing in the structures, being guided by them in action, action that takes one perhaps far beyond the point from which the 'provisions' of simple belief could return one to the place of departure, leads to an arrival at that New World of understanding. Could Heisenberg have understood the responsibility of the scientist had he not

taken it upon himself? Would he have ever realized the need for a scientific and political alliance without first making that single and comparatively small decision to remain in Germany so that true science could be preserved? Here, too, as in art, and as in science, the unfolding of structures generates new structures, new ethical connections. Again, understanding is seen as a rich process: there is given a brilliant clarity to the structures by which one has been, and will continue to be, guided, and there occurs an unfolding of new structures, as they can be realized in a specific context. For example, the concept of a relationship between scientists and politicians is the framework through which possibly new structures will unfold, or at least old structures with a new richness.

For those caught up in Heisenberg's beliefs and efforts, and aware that he feels he failed in his efforts to achieve this alliance, consolation may be taken, as it no doubt was by Heisenberg himself, in his words on Dostoevsky, that it does not matter so much if people are victorious or defeated in the struggle for goodness. What is important is that people have faith, that they decide to do something and are willing to stake their lives on it. Many have not survived their voyages to their New Worlds, but they had the courage to begin. Heisenberg himself did not, in the end, despair over his apparent lack of success in achieving that close relationship between science and politics, nor did he despair that, even

worse, science was in fact becoming increasingly preoccupied with details, instead of with the wider context; rather, a sixty-five-year-old Heisenberg trusted that "there will always be young people enough to think about the wider context, if only because they want to be absolutely honest in all things. And that being the case, their number is unimportant."[85] Certainly, Heisenberg speaks from experience when he notes that we can learn "over and over again what the word 'understanding' may mean,"[86] for the physicist believes that in humanity's search for its link with the central order, trust is without a doubt the most significant aspect of religious understanding. Unfortunately, he also realizes that trust is almost entirely missing from the modern world: "If there is much unhappiness among today's student body, the reason is not material hardship but the lack of trust that makes it too difficult for the individual to give his life a meaning."[87]

Obviously, trust cannot be delivered <u>en masse</u>; it diffuses through acting individuals, through dialogue with others, through dialogue with nature and art. Perhaps it is only after coming this far that one may understand that genuine dialogue <u>is</u> a deep form of active faith, a willingness to travel far beyond one's initial perceptions; this fully explains Heisenberg's insistence that religious understanding is only achieved through dialogue. Heisenberg's work is authentically dialogic; it draws the reader into the vital

discussion, and, if the reader is willing, directs her into expansive new regions. And this is only possible because Heisenberg himself diffuses trust; when all was said and done, Heisenberg trusted the central order, reaching that final religious understanding. It is from this immense trust, which is better imaged - as below - than described, that one concludes that the structures within Heisenberg were truly real-ized, that they shone with the splendor of truth. Surely, it is no coincidence that Heisenberg, in proclaiming his trust, unites it with his conviction of the intimate link between all the avenues to this trust; hence, he ends Der Teil und das Ganze with a poetic picture of the dialogic interplay between science, nature, art and religion - a scene "indelibly inscribed in my memory."

He recounts for the reader a family visit to a biologist friend at the Max Planck Institute for Behavioral Research, during which an afternoon of chamber music was hoped for, since the biologist was an excellent viola player and Heisenberg's own sons had musical inclinations. The sun, he remembers, streamed "unobscured" into the spacious living-room through the wide-open windows; outside, green beeches swayed under a blue sky, and brightly colored birds flew about. His friend sat between Heisenberg's two sons, and joined them in playing Beethoven's D Major Serenade, a work of the composer's youth...

> ...It brims over with vital force and joy; faith in the central order keeps casting out faint-heartedness and

> weariness. As I listened, I grew firm in the conviction that, measured on the human time scale, life, music, and science would always go on, even though we ourselves are no more than transient visitors or, in Niels' words, both spectators and actors on the great drama of life.[88]

The sun, which illuminates the gathering; glorious nature, that mirrors the divine spark within; the biologist who, so careful and cautious in his own scientific work, is yet touched by art; a dialogue of music, whose language sweeps the soul upward - Heisenberg is not merely listening to the music, but experiencing the whole, 'seeing, knowing, sensing, and believing' that life, music, and science would continue through humanity's 'forever.' Enclosed in this experience of the beautiful is the experience of understanding; for a moment, for a lifetime, Heisenberg recognizes his profound link with the central order, and recognizes that this link is always within the human grasp.

NOTES TO CHAPTER FOUR

1.Heisenberg, The Physicist's Conception of Nature, p. 66; Heisenberg, Das Naturbild der heutigen Physik, p. 45: "In der Weltgeschichte Europas, wie sie FREYER jüngst dargestellt hat und in der er von diesen Dingen spricht, ist mit Recht auch hierauf die alte Formel angewendet worden: 'Credo, ut intellegam - ich glaube, um einzusehen,' und FREYER hat sie bei dieser Anwendung auf die Entdeckungsfahrten erweitert, indem er ein Zwischenglied einfügte: 'Credo, ut agam; ago, ut intellegam - ich glaube, um zu handeln; ich handle, um einzusehen.'"

2.Heisenberg, Physics and Beyond, p. 70; Heisenberg, Der Teil und das Ganze, p. 101: "Sondern das schwerste an dieser Entdeckungsfahrt war sicher der Entschluß, alles bis dahin bekannte Land zu verlassen und so weit nach Westen zu segeln, daß mit den vorhandenen Vorräten eine Umkehr nicht mehr möglich war."

3.Heisenberg, The Physicist's Conception of Nature, p. 65; Heisenberg, Das Naturbild der heutigen Physik, p. 45: "...glauben heißt immer: Dazu entschließe ich mich, darauf stelle ich meine Existenz!"

4.Heisenberg, Encounters with Einstein, p. 132.

5.Ibid., p. 135.

6.Heisenberg, Across the Frontiers, p. 33; Heisenberg, Schritte über Grenzen, pp. 46-47: "Die Weiterbildung der Gedanken Platos hatte im Neuplatonismus und im Christentum dazu geführt, daß die Materie durch das Fehlen der Ideen charakterisiert und, da das Verstehbare identisch sei mit dem Guten, mit dem Bössen identifiziert wurde. Die Weltseele aber war schließlich in der neuzeitlichen Naturwissenschaft ersetzt worden durch das abstrakte mathematische Naturgesetz. Gegenüber dieser einseitig spiritualisierenden Tendenz stellt die alchimistische Philosophie, hier vertreten durch Fludd, ein gewisses Gegengewicht dar. Nach der alchimistischen Auffassung 'wohnt in der Materie ein Geist, der auf Erlösung harrt. Der alchimistische Laborant ist stets mit einbezogen in den Naturlauf in einer solchen Weise, daß die wirklichen oder vermeintlichen chemischen Prozesse in der Retorte mit den psychischen Worten bezeichnet werden. Die Erlösung des Stoffes durch den ihn verwandelnden Menschen, die in der Hersteelung des Steins der Weisen gipfelt, ist nach alchimistischer Auffassung zufolge der mystischen Entsprechung von Makrokosmos und Mikrokosmos identisch mit der den Menschen erlösenden Wandlung durch das Opus, das nur "Deo concedente" gelingt.'"

7.Heisenberg, Physics and Beyond, p. 154; Heisenberg, Der Teil und das Ganze, p. 212.

8.Ibid., p. 213; Heisenberg, Der Teil und das Ganze, p. 290: "Man spürt, daß der Sinn des Begriffs 'Bewußtsein' weiter und zugleich nebelhafter wird, wenn wir ihn außerhalb des menschlichen Bereichs anzuwenden suchen."

9.Ibid., p. 241; Heisenberg, Der Teil und das Ganze, p. 326.

10.Ibid; Heisenberg, Der Teil und das Ganze, p. 326: "Diese Urbilder bestimmen das ganze weitere Geschehen. Sie sind die Repräsentanten der zentralen Ordnung. Und wenn auch in der Entwicklung der Fülle der Gebilde später der Zufall eine wichtige Rolle spielt, so könnte es sein, daß auch dieser Zufall irgendwie auf die zentrale Ordnung begozen ist."

11.Ibid., p. 242; Heisenberg, Der Teil und das Ganze, p. 327: "...der Selektionsvorgang scheide die meisten dieser Versuche der Natur weider aus. Nur wenige Formen, die sich unter den gegebenen äußeren Unständen bewährten, blieben übrig."

12.Heisenberg, Across the Frontiers, p. 219; Heisenberg, Schritte über Grenzen, p. 305: "Religion ist also die Grundlage der Ethik, und die Ethik ist die Voraussetzung des Lebens. Denn wir müssen ja täglich Entscheidungen treffen, wir müssen die Werte wissen oder mindestens ahnen, nach denen wir unser Handeln ausrichten."

13.Ibid., p. 227; Heisenberg, Schritte über Grenzen, p. 315: "Die Richtigkeit bewährter naturwissenschaftlicher Ergebnisse kann vernünftiger nicht vom religiösen Denken in Zweifel gezogen werden, und umgekehrt dürfen die ethischen Forderungen, die aus dem Kern des religiösen Denkens stammen, nicht durch allzu rationale Argumente aus dem Bereich der Wissenschaft aufgeweicht werden."

14.Ibid., p. 211; Heisenberg, Schritte über Grenzen, p. 298: "Aber wenn wir ehrlich sind, müssen wir ihnen dann raten, sich an die Wertmaßstäbe zu halten, die in den großen Religionen aufbewahrt werden; denn die Zeit ist noch nicht gekommen, einen neuen Kanon zu schreiben. Eine rationalistische Analyse sozialer Verhältnisse reicht dazu ganz sicher nicht aus."

15.Heisenberg, Physics and Philosophy, p. 205.

16.Heisenberg, The Physicist's Conception of Nature, p. 53; Heisenberg, Das Naturbild der heutigen Physik, p. 37: "...daß die Beschäftigung mit der Antike im Menschen einen Wertmaßtab erzeuge, bei dem die geistigen Werte höher gelten als die materiellen. Denn gerade bei den Griechen ist der Primat des Geistigen in allen Spuren, die sie hinterlassen, unmittelbar sichtbar."

17.Heisenberg, Physics and Beyond, p. 217; Heisenberg, Der Teil und das Ganze, p. 295: "Wenn man in dieser westlichen Welt fragt, was gut und was schlecht, was erstrebenswert und was zu verdammen ist, so findet man doch immer wieder den Wertmaßstab des Christentums

auch dort, wo man mit den Bildern und Gleichnissen dieser Religion längst nichts mehr anfangen kann."

18.Heisenberg, Across the Frontiers, p. 219; Heisenberg, Schritte über Grenzen, p. 305: "Das Leben dieser Gestalten ist vom Kampf um die religiöse Wahrheit in jedem Augenblick erfüllt, es ist gewissermaßen vom christlichen Geist durchtränkt, und so spielt es nicht einmal eine besonders wichtige Rolle, ob diese Menschen im Kampf um das Gute siegen oder unterliegen. Auch die größten Schurken unter ihnen wissen noch, was gut und was böse ist, sie messen ihr Tun an den Leitbildern, die das christliche Vertrauen ihnen gegeben hat. Hier gleitet auch der bekannte Einwand gegen die christliche Religion ab, daß die Menschen sich in der christlichen Welt genauso schrecklich aufgeführt hätten wie außerhalb. Das ist zwar leider wahr, aber die Menschen bewahren in ihr ein klares Unterscheidungsvermögen von gut und böse; und nur dort, wo dies noch vorhanden ist, bleibt die Hoffnung auf Besserung."

19.Ibid.; Heisenberg, Schritte über Grenzen, p. 219: "Wo keine Leitbilder mehr den Weg bezeichnen, verschwindet mit der Wertskala auch der Sinn unseres Tun und Leidens, und am Ende können nur Negation und Verzweiflung stehen."

20.Ibid., p. 210; Heisenberg, Schritte über Grenzen, p. 297: "So ist auch die Freiheit in den Entscheidungen des Lebens nur möglich durch die Bindung an sittliche Normen, und wer diese als Zwang mißachten wollte, würde an die Stelle der Freiheit nur die Haltlosigkeit setzen."

21.Ibid.; Heisenberg, Schritte über Grenzen, pp. 296-297: "Bei der geistigen Freiheit handelt es sich auf der einen Seite um die Freiheit von Vorurteilen, von dogmatischer Bindung, von suggestiver Beeinflussung, von Gesinnungszwang. Auf der anderen um die Möglichkeit, neue Gedanken zu denken, bekannte Sachverhalte von neuen Gesichtspunkten aus anzusehen, die Gedanken anderer, auch wenn sie zunächst nicht einleuchten, mitzudenken und über sie hinauszugehen."

22.Ibid., pp. 210-211; Heisenberg, Schritte über Grenzen, p. 297: "...neue Zusammenhänge zu erkennen, neue Möglichkeiten auszukundschaften, das Ungewohnte zu denken, das kann nur unter äußerster Anstrengung gelingen. Wem es zu schwer ist, der sollte sich aber nicht dazu verleiten lassen, die bestehenden Gesetze einfach zu ignorieren. Dabei käme überhaupt nichts heraus. Sondern er tut dann gut daran, im Rahmen des schon Bestehenden zu bleiben und sorgfältige Arbeit zu leisten; das lohnt sich immer noch."

23.Heisenberg, Physics and Beyond, p. 143; Heisenberg, Der Teil und das Ganze, p. 197: "Daß Sie dazu den besten Willen haben, kann ich Ihnen nicht von vorneherein abstreiten. Aber einstweilen weiß man

doch nur sicher, daß das alte Deutschland zerstört wird, daß sehr viel Unrecht geschieht, und alles andere ist einstweilen reiner Wunschtraum. Wenn Sie versuchen würden, nur dort zu verändern und zu verbessern, wo Mißstände eingerissen sind, so könnte ich das gern gelten lassen."

24.Ibid., p. 148; Heisenberg, Der Teil und das Ganze, p. 204: "Denken Sie an jene große Revolution vor zweitausend Jahren, deren Urheber, Christus, gesagt hat: 'Ich bin nicht gekommen, das Gesetz aufzulösen, sondern zu erfüllen.'"

25.Ibid.; Heisenberg, Der Teil und das Ganze, p. 204: "...es kommt darauf an, sich auf das eine wichtige Ziel zu beschränken und sowenig wie möglich zu ändern. Das Wenige, was dann doch geändert werden muß, kann hinterher eine solche verwandelnde Kraft besitzen, daß es fast alle Lebensformen von selbst umgestaltet."

26.Some of this information is taken from Elisabeth Heisenberg's book, Inner Exile, chapter. 3, as well as W. Heisenberg's Physics and Beyond/Der Teil und das Ganze.

27.Heisenberg, Physics and Beyond, p. 149; Heisenberg, Der Teil und das Ganze, p. 206: "In den auf dieses Gespräch folgenden Wochen wurden die Eingriffe in die Univerität immer enschreckender. Einer unserer Fakultätkollegen, der Mathematiker Levy, der nach Gesetz unangefochten bleiben sollte, da er im ersten Weltkrieg viele hohe Kriegsauszeichnungen erhalten hatte, wurde plötzlich seines Postens enthoben. Die Empörung unter den jüngeren Fakultätsmitgliedern...war so groß, daß wir erwogen, von unserer Stellung an der Universität zurückzutreten und möglichst viele Kollegen zu dem gleichen Schritt zu veranlassen."

28.Ibid., p. 150; Heisenberg, Der Teil und das Ganze, pp. 206-207: "'Sie kommen, um bei mir Rat in politischen Fragen zu holen,' begann er das Gespräch, 'aber ich fürchte, ich kann Ihnen keinen Rat mehr geben. Ich habe keine Hoffnung mehr, daß sich die Katastrophe für Deutschland und damit auch für die deutschen Universitäten noch aufhalten läßt. Bevor Sie mir von den Zerstörungen in Leipzig erzählen, die sicher um nichts geringer sind als die bei uns in Berlin, will ich Ihnen lieber gleich über ein Gespräch berichten, das ich vor einigen Tagen mit Hitler geführt habe. Ich hatte gehofft, ihm klarmachen zu können, welch enormen Schaden man den deutschen Universitäten und inbesondere auch der physikalischen Forschrung in unserem Land zufügt, wenn man die jüdischen Kollegen vertreibt; wie sinnlos und zutiefst unmoralisch eine solche Handlungsweise wäre, da es sich ja zum größten Teil um Menschen handelt, die sich völlig als Deutsche fühlen und die im letzten Kriege so wie alle ihr Leben für Deutschland eingesetzt haben. Aber ich habe bei Hitler keinerlei Verständnis gefunden - oder schlimmer, es gibt einfach keine Sprache, in der man sich mit einem solchen Menschen überhaupt verständigen kann. Hitler hat, so schien mir, jeden wirklichen

Kontakt mit der Außenwelt verloren...[er] wird Deutschland in eine entsetzliche Katastrophe führen.'"

29.Ibid., p. 151; Heisenberg, Der Teil und das Ganze, pp. 207-208: "'Sehen Sie, man kann eine Lawine, die einmal Bewegung geraten ist, nicht mehr in ihrem Lauf beeinflussen. Wieviel sie zerstören, wie viele Menschenleben sie vernichten wird, das ist durch die Naturgesetze schon entschieden, auch wenn man es noch nicht weiß. Auch Hitler kann den Lauf der Ereignisse nicht mehr wirklich bestimmen; denn er ist ja in viel höherem Maße ein von seiner Besessenheit Getriebener als Treibender. Er kann nicht wissen, ob die Gewalten, die er entfesselt hat, ihn schließlich hoch emporheben oder jämmerlich vernichten werden.'"

30.Ibid.; Heisenberg, Der Teil und das Ganze, p. 208: "...vielleicht wären Sie bereit, hier vieles in Kauf zu nehmen..."

31.Ibid.; Heisenberg, Der Teil und das Ganze, p. 208: "'...aber für das Leben in unserem Land wird alles, was Sie tun, bestenfalls nach dem Ende wirksam werden.'"

32.Ibid.; Heisenberg, Der Teil und das Ganze, p. 208: "'Sie würden dann im Ausland der großen Menge derer, die auswandern und eine Stellung suchen müssen, zugerechnet werden, und vielleicht einem anderen, der in größerer Not ist als Sie, indirekt eine Stelle wegnehmen. Sie könnten dort wahrscheinlich ruhig arbeiten, Sie wären außer Gefahr, und nach dem Ende der Katastrophe könnten Sie, wenn Sie den Wunsch haben, nach Deutschland zurückkehren - mit dem guten Gewissen, daß Sie nie Kompromisse mit den Zerstörern Deutschlands geschlossen haben. Aber bis dahin sind vielleicht viele Jahre vergangen, Sie sind anders geworden, und die Menschen in Deutschland sind anders geworden; und es ist sehr fraglich, wieviel Sie in dieser veränderten Welt dann wirken könnten.'"

33.Ibid.; Heisenberg, Der Teil und das Ganze, p. 208: "'Wenn Sie nicht zurücktreten und hier bleiben, haben Sie eine Aufgabe ganz anderer Art. Sie können die Katastrophe nicht aufhalten und müssen, um überleben zu können, sogar immer wieder irgendwelche Kompromisse schließen. Aber Sie können versuchen, mit anderen zusammen Inseln des Bestandes zu bilden. Sie können junge Menschen um sich sammeln, ihnen zeigen, wie man gute Wissenschaft macht und ihnen dadurch auch die alten richtigen Wertmaßstäbe im Bewußtsein bewahren.'"

34.Ibid.; Heisenberg, Der Teil und das Ganze, p. 209: "'Denn solche Gruppen können Kristallisationskeime darstellen, von denen aus sich die neuen Lebensformen bilden.'"

35.Ibid.; Heisenberg, Der Teil und das Ganze, p. 209: "'Aber in einer solchen entsetzlichen Situation, wie wir sie jetzt in Deutschland vorfinden, kann man nicht mehr richtig handeln. Bei jeder Entscheidung, die man zu treffen hat, beteiligt man sich an

irgendeiner Art von Unrecht. Daher ist auch letzten Endes jeder auf sich allein gestellt. Es hat keinen Sinn mehr, Ratschläge zu geben oder anzunehmen. Daher kann ich auch Ihnen nur sagen, machen Sie sich keine Hoffnungen, daß Sie, was immer Sie tun, bis zum Ende der Katastrophe viel Unglück verhindern könnten. Aber denken Sie bei Ihrer Entscheidung an die Zeit, die danach kommt.'"

36.Ibid., p. 152; Heisenberg, Der Teil und das Ganze, pp. 209-210: "Fast beneidete ich die Freunde, denen die Lebensgrundlage in Deutschland mit Gewalt entzogen worden war und die daher wußten, daß sie unser Land verlassen mußten. Ihnen war bitter Unrecht geschehen, und sie hatten große materielle Schwierigkeiten zu überwinden, aber ihnen war wenigstens die Wahl erspart."

37.Ibid.; Heisenberg, Der Teil und das Ganze, p. 211: "Und hieß Auswandern nicht, unser Land kampflos einer Gruppe von besessenen Menschen zu überlassen, die seelisch aus dem Gleichgewicht geraten waren und die in ihrer Verwirrung Deutschland in ein unübersehbares Unheil stürzten?"

38.Heisenberg, "Scientific Truth and Religious Truth," p. 10; Heisenberg, Schritte über Grenzen, p. 310: "...daß sich der Konflikt zwischen den Naturwissenschaft und der herrschenden Weltanschauung auch noch in unserer Zeit abspielt, und zwar gerade in den totalitären Staatsgebilden, in denen der dialektische Materialismus als Grundlage des Dekens gewählt worden ist. So hat es die offizielle Sowjetphilosophie schwer gehabt, sich mit Relativitätstheorie und Quantentheorie abzufinden; insbesondere in den Fragen der Kosmologie sind die Meinungen dort hart aufeinandergeprallt."

39.Heisenberg, Physics and Beyond, p. 154; Heisenberg, Der Teil und das Ganze, p. 212: "Dazu kam mir ein Gespräch mit Niels in den Sinn, der von einer Komplementarität der Begriffe 'Gerechtigkeit' und 'Liebe' gesprochen hatte."

40.Ibid.; Heisenberg, Der Teil und das Ganze, p. 212: "Die Gerechtigkeit gebietet dem Juristen, die Unterschrift zu verweigern. Auch würden die politischen Folgen der Unterschrift vielleicht viel mehr Menschen ins Unglück stürzen als nur die neun Freunde. Aber darf sich die Liebe dem Hilferuf verschließen, den die verzweifelten Angehörigen der Freunde an den Juristen richten?"

41.Ibid.; Heisenberg, Der Teil und das Ganze, p. 212: "Dann kam es mir wieder kindisch vor, solche absurden Gedankenspiele zu betreiben."

42.Ibid., p. 154; Heisenberg, Der Teil und das Ganze, p. 212: "Also: Inseln des Bestandes bilden, junge Leute sammeln und sie nach Möglichkeit lebendig durch die Katastrophe bringen, und dann nach dem Ende wieder neu aufbauen; das war die Aufgabe, von der Planck gesprochen hatte. Dazu gehörte wohl unvermeidlich,

Kompromisse schließen und später dafür mit Recht bestraft werden - und vielleicht noch Schlimmeres. Aber es war wenigstens eine klar gestellte Aufgabe. Draußen wäre man eigentlich überflussig. Dort gab es nur Aufgaben, die von vielen anderen besser geleistet werden konnten."

43.Ibid., p. 165; Heisenberg, Der Teil und das Ganze, p. 226: "...eine Zeit unendlicher Einsamkeit..."

44.Ibid.; Heisenberg, Der Teil und das Ganze, p. 226: " Dazu kam die Vereinsamung des Einzelnen in Deutschland selbst."

45.Ibid.; Heisenberg, Der Teil und das Ganze, p. 226: "...und die Einsicht, daß am Ende dieser Entwicklung nur eine totale Katastrophe für Deutschland stehen könnte, machte mir unerbittlich klar, wie schwer die Aufgabe war, die ich mir seit meinem Besuch bei Planck gestellt hatte."

46.Ibid., p. 229; Adenauer's remarks seem to be somewhat more seriously spoken in the original German, perhaps bringing out more clearly the depth of that "wisdom": " Das katholische Denken enthält einen Anteil östlicher Philosophie und Lebensweisheit, und es war wohl gerade dieser Anteil, aus den Adenauer in schwierigen Lagen Kraft schöpfte. Ich erinnere mich an ein Gespräch, in dem wir uns über die Erlebnisse in der Gefangenschaft unterhielten. Da Adenauer eine Zeitlang von der Gestapo in eine Gefängniszelle bei kärglichster Verpflegung eingesperrt worden war, ich aber nur eine relativ angenehme Internierung in England mitgemacht hatte, fragte ich ihn, ob ihm diese Zeit sehr schwer geworden sei. Adenauer meinte: 'Ach, wissen Sie, wenn man so in einer engen Zelle eingeschlossen ist, Tage, Wochen, Monate, wenn man von keinen Telefonanruf und keinem Besucher gestört wird, dann kann man sinnieren, ganz still über das Vergangene nachdenken und über das, was vielleicht noch kommen kann, ganz ruhig, ganz mit sich allein, das ist doch eigentlich sehr schön,'" Heisenberg, Der Teil und das Ganze, pp. 310-311.

Also, although Heisenberg does not mention it, in this connection, it is interesting to remember Arthur Koestler's immediate experience with the ultimate, as he waited in a small prison cell for his execution.

47.The English title of his wife's biographical writings on Heisenberg, originally titled Das politische Leben eines Unpolitischen - Erinnerungen an Werner Heisenberg.

48.Ibid., p. 184; Heisenberg, Der Teil und das Ganze, p. 251: "...nicht über die Kriegslage, denn die war zu offensichtlich, um noch vieler Worte zu bedürfen, sondern über Hoffnung und Pläne für die Zeit nach dem Kriege."

49.Heisenberg, The Physicist's Conception of Nature, p. 24; Heisenberg, Das Naturbild der heutigen Physik, p. 18: "Der Weg zu diesem Ziel [i.e. die Sicherheit in den Regungen des Geistes] wird lang und mühevoll sein, und wir wissen micht, welche Leidensstation noch auf ihm liegen."

50.Heisenberg, Physics and Beyond, p. 165; Heisenberg, Der Teil und das Ganze, p. 227: "Ich war, während ich mit der Sammelbüchse umherging, in einem Zustand völliger Verzweiflung. Nicht wegen der verlangten Geste der Unterordnung, die mir unwichtig schien, sondern wegen der völligen Sinn- und Hoffnungslosigkeit dessen, was ich tat und was sich um mich herum abspielte."

51.Ibid., p. 166; Heisenberg, Der Teil und das Ganze, p. 227: "hinter diesen schemenhaften Gestalten und dem grauen Himmel empfand ich eine starke Helligkeit. Es fiel mir auf, daß einige Menschen mir besonders freundlich begegneten und mir ihren Beitrag mit einem Blick reichten, der mich für einen Moment aus meiner Ferne zurückholte und mich dann eng mit ihnen verband."

52.Ibid., p. 166; Heisenberg, Der Teil und das Ganze, p. 227: "Aber dann war ich wieder weit weg und begann zu spüren, daß diese äußerst Einsamkeit vielleicht über meine Kräfte gehen könnte."

53.Ibid.; Heisenberg, Der Teil und das Ganze, p. 227: "Diesmal hatte ich Angst vor der Musik und der Begegnung mit neuen Menschen. In meinem schlechten Zustand fühlte ich mich den Anforderungen eines solchen Abends nicht gewachsen, und ich war daher froh zu sehen, daß der Kreis der Besucher nur klein war. Eine der jungen Zuhörerinnen, die zum ersten Mal im Hause Bücking verkehrte, konnte schon bei unserem ersten Gespräch die Ferne überbrücken, in die ich an diesem merkwürdigen Tag geraten war. Ich spürte, wie die Wirklichkeit mir wieder näher rückte, und der langsame Satz des Trios wurde von meiner Seite schon eine Fortsetzung des Gesprächs mit dieser Zuhörerin."

54.Elisabeth Heisenberg, Inner Exile, p. 57. She also details the above compromise.

55.For example, one of Heisenberg's interrogators after the war, Samuel Goudsmit, wrote Alsos, in which German physicists - Heisenberg in particular - were portrayed in so distorted a manner that American newspapers were prompted to print in large, bold-faced headlines: "TOP-NAZI Heisenberg." The Nobel Prize-winning physicist seemed to understand this public loss of reputation as simply another price paid for his decision to stay in Germany. His wife writes that "Heisenberg had long resigned himself to the fact: 'You know,' he said to me, 'history is always written by the victor; you just have to live with that'" (Inner Exile, p. 112).

56.Heisenberg, Physics and Beyond, p.182; Heisenberg, Der Teil und das Ganze, p. 247: "Da ich fürchten mußte, daß Niels von deutschen Stellen überwacht würde, sprach ich mit äußerster Vorsicht, um nicht später auf irgendeine bestimmte Äußerung festgelegt werden zu können."

57.Ibid., p. 182; Heisenberg, Der Teil und das Ganze, p. 248: "...und vielleicht hinderte ihn auch die berechtigte Erbitterung über die gewaltsame Besetzung seines Landes durch deutsche Truppen daran, eine Verständigung der Physiker über die Grenzen der Länder hinweg überhaupt in Betracht zu ziehen. Es war für mich sehr schmerzlich zu sehen, wie vollständig die Isolierung war, in die unsere Politik uns Deutsche geführt hatte, und zu erkennen, daß die Wirklichkeit des Krieges auch Jahrzehnte alte menschliche Beziehungen wenigstens zeitweise zu unterbrechen vermag."

58.For example, Augustine notes of the creation of cities, farms, and systems of communication, "Great are these achievements, and distinctly human." However, he too speaks of the neutrality of scientia: "Yet this heritage common to all rational souls, is shared in by the learned and unlearned, by the good and the wicked." De Quantitate Animae, 33, 72.

59.Ibid., p. 197; Heisenberg, Der Teil und das Ganze, p. 268: "Man hat also einen Sieg Hitlers durch die Atombombe für eine so entsetzliche Gefahr gehalten, daß zur Abwendung dieser Katastrophe auch das Mittel der eigenen Atombombe gerechtfertig schien."

60.Ibid., p. 200; Heisenberg, Der Teil und das Ganze, p. 273: "Ich weiß nicht, ob wir in diesem Zusammenhang das Wort 'Vorwurf' überhaupt in den Mund nehmen dürfen. Wahrscheinlich haben wir an dieser einen Stelle einfach mehr Glück gehabt als unsere Freunde auf der anderen Seite des Ozeans."

61.Ibid. (revised translation), p. 197; Heisenberg, Der Teil und das Ganze, p. 268: "Nach dem Ende des Krieges mit Deutschland haben wahrscheinlich viele Physiker in Amerika von der Anwendung dieser Waffe abgeraten, aber sie hatten um diese Zeit keinen entscheidenden Einfluß mehr."

62.Ibid., p. 199; Heisenberg, Der Teil und das Ganze, p. 272: "'Das würde wohl bedeuten, daß er sich auch um eine Verbindung mit dem öffentlichen Leben, um Einfluß auf die staatliche Verwaltung bemühen muß, wenn er das Richtige nicht nur denken, sondern auch tun und bewirken will."

63.Ibid., p. 203; Heisenberg, Der Teil und das Ganze, p. 277: "...sondern mir war das Eindringen des wissenschaftlichen, inbesondere des naturwissenschaftlichen Denkens in die Regierungsarbeit mindestens ebenso wichtig."

64.Ibid.; Heisenberg, Der Teil und das Ganze, p. 277: "Es war ja leicht zu erkennen, daß die aus dem wissenschaftlichen Fortschritt entstehende Technik eine außerordentlich wichtige Rolle, nicht nur beim materiellen Aufbau der Städte und der Industrie, sondern darüber hinaus auch in der ganzen sozialen Struktur unseres Landes und Europas spielen würde."

65.Heisenberg, Physics and Philosophy, p. 192.

66.Heisenberg, Across the Frontiers, p. 103; Heisenberg, Schritte über Grenzen, p. 186: "Vielleicht wird doch eher der die Herzen der Menschen gewinnen, der hohe Ziele setzt und der sich wirklich am gemeinsamen Aufbau dieser merkwürdigen modernen Welt beteiligen will. Denn nur wer mittut, kann auch die Richtung dieser Welt in dem Sinne beeinflussen, den er selbst für wünschenswert hält."

67.Heisenberg, Physics and Philosophy, p. 192.

68.Ibid.

69.Ibid., p. 200

70.Heisenberg, Across the Frontiers, p. 66; Heisenberg, Schritte über Grenzen, p. 147: "...er darf sich nicht durch Vorurteile oder Illusionen blenden lassen, er muß auf alle jene im politischen Leben oft so gefährlichen Vereinfachungen verzichten, wenn er der ihm übertragenen Verantwortung wirklich gerecht werden, in ihr Erfolg haben will."

71.Ibid., p. 68; Heisenberg, Schritte über Grenzen, p. 149: "Trotzdem mögen auch von hier schon Einflüsse auf das Denken der Menschen im großen ausgehen."

72.Ibid., p. 69; Heisenberg, Schritte über Grenzen, p. 150: "Im Hinblick auf die großen politischen Gefahren unserer Zeit kann man hoffen, daß sich das Gefühl ausbreitet, das ein russischer Physiker kürzlich auf einem internationalen Kongreß in dem Satz ausgesprochen hat: 'Wir reisen zusammen auf einem Raumschiff, das sich, schon seit undenklichen Zeiten um die Sonne kreisend, mit ihr, dem großen Stern, durch unendliche Räume bewegt. Woher und wohin, wissen wir nicht; aber wir reisen gemeinsam auf dem gleichen Schiff.'"

73.Heisenberg, Physics and Beyond, p. 204; Heisenberg, Der Teil und das Ganze, p. 278: "Es gelang mir nicht, die Vertreter der Hochschulen von den neuen Notwendigkeiten zu überzeugen, und es entstand eine Forschungsgemeinschaft, die zunächst doch die alten Traditionen der früheren Notgemeinschaft in wesentlichen Punkten fortsetzte."

74.Ibid.(revised translation), p. 220; Heisenberg, Der Teil und das Ganze, p. 298: "Es beunruhigte mich, daß für die Menschen, die hier die wichtigsten Entscheidungen zu treffen hatten, die Grenzen zwischen friedlicher Atomtechnik und atomarer Waffentechnik ebenso fließend waren wie die zwischen Atomtechnik und atomarer Grundlagenforschung."

75.Ibid., p.226; Heisenberg, Der Teil und das Ganze, p. 307: "Vielmehr mußten wir uns ganz bestimmte Ziele setzen, die unter den gegebenen Umständen auch wahrscheinlich erreicht werden konnten."

76.Ibid. (revised translation), p. 222; Heisenberg, Der Teil und das Ganze, p. 301: "Wenn man öffentlich ausspricht, daß man für den Frieden und gegen die Atombombe sei, so ist das doch dummes Geschwärtz. Denn jeder Mensch, der seine gesunden fünf Sinne beieinander hat, ist von selbst für den Frieden und gegen die Atombombe und braucht dazu keine Erklärung von Wissenschaftlern. Die Regierungen werden solche Kundgebungen in ihren politischen Kalkül einbeziehen, sie werden selbst für den Frieden und gegen die Atombombe sein und im Nebensatz hinzufügen, daß natürlich ein Friede gemeint sei, der für das eigene Volk günstig und ehrenvoll ist, und daß es sich vor allem um die verwerflichen Atombomben der anderen handle. Damit ist doch gar nichts gewonnen."

77.Heisenberg, Physics and Philosophy, p. 192.

78.Ibid.

79.Heisenberg, Physics and Beyond, p. 172; Heisenberg, Der Teil und das Ganze, p. 235: "'Zunächst handelt es sich ja um sehr interessante Physik, und wenn Frieden wäre und es um nichts anderes ginge, so würden wir uns wohl alle freuen, an einem Problem von solcher Tragweite mitzuarbeiten.'"

80.Heisenberg, "Tradition in Science," p. 50.

81.Heisenberg, Physics and Philosophy, p. 141.

82.Heisenberg, Physics and Beyond, p. 199; Heisenberg, Der Teil und das Ganze, p. 272: "'Wir haben immerhin verstanden...daß es für den Einzelnen, dem der wissenschaftliche oder technische Fortschritt eine wichtige Aufgabe gestellt hat, nicht genügt, nur an diese Aufgabe zu denken. Er muß die Lösung als Teil einer großen Entwicklung sehen, die er offenbar bejaht, wenn er überhaupt an solchen Problemen mitarbeitet. Er wird leichter zu den richtigen Entscheidungen kommen, wenn er diese allgemeinen Zusammenhänge mit bedenkt.'"

83.Ibid., p. 147; Heisenberg, Der Teil und das Ganze, p. 203: "...daß man gewissenhaft und ordentlich seine Arbeit machen und dabei hoffen soll, daß das gute Beispiel schließlich auch zum Guten wirkt."

84.Heisenberg, Across the Frontiers, p. 228; Heisenberg, Schritte über Grenzen, p. 315: "Es wird darauf ankommen, die in der geistigen Gestalt der Gemeinschaft begründeten Werte wieder im Alltag lebendig zu machen, ihnen so viel Leuchtkraft zu verleihen, daß sich das Leben des Einzelnen wieder von selbst nach ihnen richtet."

85.Heisenberg, Physics and Beyond, p. 246; Heisenberg, Der Teil und das Ganze, p. 333: "Es wird immer wieder junge Menschen geben, die auch über die großen Zusammenhänge nachdenken, schon weil sie bis zum Letzten ehrlich sein wollen, und dann kommt es ja nicht darauf an, wie viele es sind."

86.Ibid., p. 124.

87.Heisenberg, Across the Frontiers, p. 228; Heisenberg, Schritte über Grenzen, p. 315: "Wenn es viel Unglück in der heutigen studentischen Jugend gibt, so ist der Grund dafür nicht materielle Not, sondern der Mangel an Vertauen, der es dem Einzelnen zu schwer macht, seinem Leben eine Sinn zu geben."

88.Heisenberg, Physics and Beyond, pp. 246-247; Heisenberg, Der Teil und das Ganze, p. 334: "...die von Lebenskraft und Freude überquillt und in der sich Vertauen in die zentrale Ordnung überall gegen Kleinmut und Müdigkeit durchsetzt. In ihr verdichtete sich für mich beim Zuhören die Gewißheit, daß es, in menschlichen Zeitmaßen gemessen, immer wieder weitergehen wird, das Leben, die Musik, die Wissenschaft; auch wenn wir selbst nur für kurze Zeit mitwirken können - nach Niels' Worten immer zugleich Zuschauer und Mitspieler im großen Drama des Lebens."

CONCLUSION

Heisenberg has rightly noted that the results of a scientist discussing philosophy might be so useful that it is worth running the risk. He also correctly asserted that, in our time, science must be the foothold by which this re-visioning can be achieved, and for a number of reasons. In the clearest instance, science has held the highest authority in the modern world; it has shaped this world in many ways, including the way in which the world shapes its thoughts. Heisenberg agreed with von Weiszäcker's contention that, because of this, it matters very much what physicists think; elsewhere, von Weiszäcker has called scientists the "priests" of our age, and one cannot help but expect Heisenberg to concur with this as well, at least as a metaphor. Obviously, he would not even give it this much validity if he did not believe that there was profound content in science, and that the scientist in some respects did serve as a mediator between the divine and his worshippers. It is because he believes this, and because it is possible for the world, enfolded as it is in quantitative thought, to grasp the structures of which science speaks, that he is convinced what physicists had to say was important. At the moment, it really does have the highest, and most effective, authority. Hence, as mentioned above, given the trust which the world places in a mathematical understanding of nature, and in those who understand it, that admission by science that it is concerned

with very special structures, and its demonstration of that fact, opens the doors to the rest of human reality.

Of course, this is not a reality neglected by the scientists themselves; that is, the physicists of our time have not merely demonstrated the limits of science, attempted what was possible within those limits, and then stepped aside to let the philosophers do their work. It should be more than clear by this point that, at least in Heisenberg's case, a good deal of his philosophical thought developed in conjunction with his work in physics. No doubt this can also be said of many other physicists and scientists: Kepler, Newton, Bohr, Pauli, von Weiszäcker, Schrödinger, Wheeler, and Prigogine, to name a very few. It appears that those limits are determined by a wider understanding of reality; they are included in that larger reality. It is true that no scientist can come to his work in complete isolation; he brings with him the ideas and assumptions of various traditions, and this, as we have discovered, is not undesirable. On the contrary, no work is possible without it. However, those ideas and assumptions are not unchanged through the course of the scientific work, that is, nature has something to say to those ideas, which may have to be adapted to suit nature. Our concern is with those thoughtful scientists who were dealing with entirely new problems, who could not attempt to understand those problems without a complete re-visioning, and

who found it necessary and fruitful to bring that re-visioning into the larger reality.

A possible illustration of the contemporary situation is found in the material philosophising of the ancient Greeks; leaving behind 'myth', they approached reality through the material, only to discover that their insights unfolded into the world of the human spirit. Heisenberg has shown that ideas of these ancient materialists are not to be discounted in the realm of the scientific; neither are they to be discounted in the larger realm. For example, Thales' theorized that the material cause for all things is water, but life is inherent in this substance, since he believed that all things are full of gods; obviously, this idea of a sacred nature would have great implications for the human, and moves far beyond the initial aim of understanding matter. The Pythagorian conception is a better example: in the resolution of the question of the "one" and the "many" in the physical world, the discovery that reality lay in ordering principles of form and measure, proportion and number, rather than in the unordered and indefinite principle of matter, almost naturally led to its application in the realm of the human spirit.

In fact, humans seem to have always found that their knowledge of the nature of nature says something about themselves and their human world. Over and over humanity assumes its connection to nature, although at different times to greater and lesser extents. But that connection exists, and

what we learn about nature is often reflected in our thoughts about our own nature. We need only recall how quickly after the mechanized view of nature was developed that the human became a 'machine,' albeit with a ghost in the mechanism. Of course, the West is now slowly exorcising this ghost, returning to humanity its fullness, a fullness that comes with its natural connection to nature, and no doubt in a large part this can be attributed to the directions science has taken this century. Work in quantum physics has discovered a great many things about the nature of nature, and in the process, a great many things about ourselves.

For instance, at least in Heisenberg's view, nature is not strictly causal - nature at the most basic level seems to make choices, although choices which seem to fall into a greater 'plan'. Recent work in other levels of nature, chaos studies, also seem to confirm nature's creative abilities. There is, of course, a danger of too quickly transferring these discoveries into the study of human nature, and one may read of the confirmation of Christian "free will" via quantum mechanics. One may admit that it is important to realize that nature is not a clockwork machine, though it can, for special purposes, be seen that way; as natural beings, this will apply to us as well. However, at a higher level, it suggests something profound about the nature of nature, perhaps a world soul. And, if 'all things are full of gods', so to speak, then the implication for our own selves is equally profound. For

example, if a living nature is creatively attempting to express itself, to purposely manifest certain structures, then it follows that there is a purpose to its manifestation of the human. Some scientists in this century have speculated that the human was necessary, so that the universe might achieve 'self-consciousness'. From this the question would follow - of what is it that we are conscious? - simply returning us to the question of self-understanding. But this is merely an illustration.

The great scientists of this century, and in any century, have found themselves unable to remain quiet in the face of these implications, be they these exactly, or some others that have taken them far beyond the scope of their initial physical investigation. It is quite clear in Heisenberg's case that the physicist is unwilling - unable, it is easily argued - to simply remain with his work in physics, since the methods, aims and discoveries of his science are part of a much larger whole. Again, for those who have thought about it carefully, discovering the nature of nature cannot but help us to discover something about our own nature. Of course, the discovery and fulfilment of that true human nature has been understood by many of the great religious traditions to be human salvation.

It is, then, important for our time to listen to the scientists, not only because they have shaped our modern way of thought, and can best speak to it, but because what they

have to say is in fact significant and very much worth our serious consideration. Thus, when it is suggested that science has, in discovering its limits, opened the doors to a larger reality, it is not that science has simply opened those doors to let the world fend for its spiritual self. Science has not simply re-drawn the borders; it has become intimately involved in that process of religious dialogue. Perhaps no scientist was more involved in that dialogue than Heisenberg, who believed that science could add so much to the process. Hence, we are obliged to listen to Heisenberg, and to listen closely.

As significant as his scientific thought is, it certainly appears that Heisenberg's understanding of science as an avenue to religious understanding could never have been realized through an isolated study of his scientific ideas. He neither approached it in isolation, nor did he leave it in such. Of course, it may be possible to focus on only the scientific, but, if one is to take Heisenberg seriously (as we have tried to do), and always keep the wider context in view, then his scientific notions simply cannot be left in isolation: to do so would make them meaningless. That his scientific understanding had an immense impact on him is quite plain, and although no effort was made here to precisely clarify the influence of that understanding on his artistic and ethical, there can be no question that his natural understanding did have a profound influence. But he was

himself aware of the danger of the vision of the dazzling parts. Hence, nothing was taken more seriously in this attempt to re-present Heisenberg's vision of science as an avenue to that religious understanding than his statement that "Clarity is gained through fullness." It is here felt that the discussion of the physicist's ideas beyond those of science produced incredibly worthwhile results. The additional aspects upon which we focused, then, should be considered more than mere background to his scientific thought; by now it should be quite clear that his religious perceptions, those of the artistic, scientific and ethical, are all interconnected, like that artistic ribbon decoration of the Arab mosque, where the alteration of a single leaf would crucially disturb the connection to the whole. Only when the decorations are viewed as a whole, only when one absorbs the total, undisturbed beauty, does that design truly express the spirit of the religious understanding from which it has arisen. Hence, dissimilar as they might first seem, all the areas investigated above are connected by more than their method of understanding, though this is significant enough to be reviewed a final time.

For Heisenberg, religion is the concern with the human relatedness to the central order, that is, the discovery of our connectedness to God. Actually, it can be said that for the physicist, it is a rediscovery, since the foundation of Heisenberg's thought, that which allows the corresponding

modes of understanding through art, science, and act-ive understanding, without a doubt rests in his Platonic/Christian understanding of the soul as that image of the One, the soul as possessing a spark of the divine; hence, the discovery lies in the unveiling of the inner structures, enabling a deep and lasting recognition of the divine within - our most vital relation. Any religious activity, then, is that which works to this unveiling, and, given the nature of the soul, works to it in essentially the same way; as Heisenberg says, the possibility to be realized influences the course of events. What is necessary to the uncovering of the inner core are outside reminders, so to speak, of those structures within.

Of course, the process of understanding itself, the realization of these inner structures, is by no means a simple one, in Heisenberg's eyes: he argues that there can be no understanding without specific content, which determines the concept abstraction from the archetypal images. From the concept, used as a vehicle to realization, a basic form or structure is initiated, which is considered objective and eternal by Heisenberg. The artist's and scientist's work, as well as the right actions of the individual, if guided by the compass of the central order - a qualification that can never be emphasized enough, - consists of unfolding that structure, in order that its richness be understood. It is true, though, that the structures unfolded in each area will be of a different order, because of the distinct language appropriate

to each. For example, the intricate language of art is one which science has relinquished in order to gain insight into special structures, and the language of action is even more complex than that of art, since that language involves the total giving of the self. Furthermore, it is only through this unfolding of the structures through the appropriate language that other concepts and structures are brought to light, thus firmly rooting the ground of ideas. In so firm a base of recognized structures, the soul is swept upward to the highest light, the One, as it has been implanted in the soul, a realization which applies both individually and communally. That ground for Heisenberg is a firm one. However, since it is possible to reinforce the ground through fullness, since clarity is gained through that fullness, the quest for understanding should never end.

Here, of course, Heisenberg does not simply mean that the search for understanding cannot end in a field when one 'truth' has been discovered; as he remarks, the unfolding of structures is <u>bound</u> to lead the world to the discovery of new structures, particularly when that process is guided by a vision of the one, the good, and the true. This process is a spontaneous one. Naturally, however, those complacent individuals lacking the proper vision might need to be reminded of this. Rather, to those others genuinely involved in the quest, Heisenberg would suggest a further anchoring of the ground through a widening of it, a widening that possesses

depth as well as breadth. But this widening of the ground must not be conceived of as a disjointed 'grouping together' of dissimilar structures, which, though arrived at in a corresponding manner, have no true connection to each other. For Heisenberg, at least, there is a very real connection through mutual enrichment and reinforcement.

For example, without the art by which the towering structures were unveiled within the physicist, by which Heisenberg found his certain link to the central order, it is doubtful that he could have approached science with the certainty that the structures of nature could be uncovered and understood. Neither would he have understood the crucial necessity of scientific discovery, that it was a path to the One, since abstract, mathematical science alone cannot direct its vision there. Of course, fully aware that science could speak only of special structures, and not those vital structures of value, Heisenberg emphasizes the continued and essential need for art, particularly as it expresses religious understanding, with its own vision directed to the central order; the attempts at a fragmented imitation of scientific abstraction are seriously confused, since only those fully informed of the nature of scientific abstraction understand the merits, and cost, of that abstraction. Yet, for Heisenberg, the admission by science that it does deal in special structures, and cannot claim to explain or understand all of human reality, is only a part of the re-appreciation

and revitalization of art: although it was through quantum physics that the 'truths' of Newtonian science were placed in their appropriate realm, it was also through quantum physics that true reality was discovered not in the material, but in the ideal. The ancient understanding and aims of art are thus enriched in a very immediate manner.

The unveiling of structures in the soul, both of order and of value, where the latter, as we noted, is simply order of a more complex kind, established and reinforced the basis of Heisenberg's life, that is, the foundation from which he was to act. They imparted to him the faith, the trust, that enabled his bold leaps forward, whether the leap was the one to remain in Germany during the war, that science might emerge untainted, or the attempts to connect the worlds of science and politics, that the force of science and technology be rightly guided. In the former, there is little doubt that his efforts succeeded, that his faith enabled a victory for his one, single, objective. It is of no small significance to Heisenberg that his efforts, and of course the efforts of like-minded scientists, provided a strong foundation to those whom he had gathered around him, and after the war, allowed a continuation of the search for scientific truth; in a very practical way, action contributed to further opportunities for understanding in the native land, where Heisenberg feels the scientist will feel most at home and do his best work (much as he felt that those who remain in and are dedicated to the

sources of vitality in the West will come to the greatest insights). In his latter notion, what is important is that the action he asks particularly - but not exclusively - of scientists necessitates a return to the insights of their own work, and to the insights of art, and thus religion.

Clearly, then, Heisenberg is convinced of the connection of all the avenues to religious understanding, a connection which broadens and secures the ground of ideas in both a theoretical and practical sense, as those ideas must be realized in the world. It is of the utmost importance to the physicist that individuals do realize and manifest the total connection within themselves; only then can the great interconnectedness can be realized and manifested in the world. It is only through this individual, act-ive faith (painting a picture, being moved by a symphony, upholding true science, choosing to love) that the structures within are truly understood, that trust in the meaning of one's life develops, a personal trust which consequently develops into a profounder trust in the meaning of the total superstructure. Heisenberg seems certain that this trust is a dynamic order, which will diffuse - unfold - through the world, urging it to a confident approach to the bottomless well of understanding; others must see the outer structures before they realize their own inner structures. Fresh understanding, both of the artist and the audience, the scientist and the student, the lover and the beloved, will bring fresh trust to each new age of

humanity, and over and over again a re-visioning of the great interconnection between art and science, ethics and religion, and humanity and the One.

Fascinating as this revitalization of an ancient tradition may be, what is perhaps more important is his early recognition of the basic problem which prompted that life-long revitalization: the absence of a unifying centre, an absence that once caused him an almost physical suffering. Certainly, we can characterize the world today as suffering in the same way, and the absence of such a centre is clear in many areas. Heisenberg spoke of that lack in scientific research, which is seen in the overwhelming pre-occupation with details; technological research has lost it as well, with disastrous consequences. The physicist also mentions the absence of that unifying centre in connection with art, an absence which has rendered it, in his opinion, impotent, unable to draw the soul upwards. In addition, organized religion has lost that unifying centre; one need only observe as churches splinter into smaller and smaller sects. The study of religion, in many instances, can also be charged with this loss of centre; knowledge, for its own sake, or for the sake of upholding one particular set of convictions, means very little in the wider scheme of things. Without a proper guide, without a working compass, all such endeavors do sail around in circles, not even aware that there is a destination. Without a goal, what is the point of making the journey?

What we have seen particularly in Heisenberg is a renewal of the unifying centre, a deep concern with the relatedness to the central order, which to him is nothing more that the realization of self. This is not surprising to see: that ancient tradition, that perennial philosophy, has always had adherents, and one can hear them in each age. Some stars will always shine. What seems to be occurring, however, is something much more exciting, perhaps the coming to light of a new galaxy of stars, the unfolding of a new spirit of the time. It may well be that Heisenberg is one of the first of this new galaxy; this would account for his general neglect: if the world is not quite ready for a work of art, if the spirit of the time which generated it has not yet filtered through deeply enough, then that work will simply not be appreciated, nor understood. True, his fundamental philosophy is not 'new', so to speak, but he has visioned it in a way that is appropriate for our time, and by doing so, he has opened the doors to entirely new insights. By this, we mean he has visioned it in the framework of an immense dialogue, a clarity gained through fullness. For example, he saw science suited to be the first strong connection between different cultural traditions, simply because the ultimate decisions about the value of a special scientific work, about what is correct or wrong in the work, do not depend on any human authority; in the end, those decisions are made by nature itself. He feels that this connection is a crucial one, since

further insights will come from diverse backgrounds. Of course, for him, these insights are qualified by the necessity of utter devotion and careful work and attention to detail, a genuine interest in the truth, rather than interest in pet theories or scientific ideologies. For Heisenberg, truth can be found in many endeavours, science, art, action, philosophy, and religion, as long as the partners in dialogue are guided by the compass of the central order, however one genuinely experiences and understands it.

But Heisenberg is not alone in his efforts to renew that concern for the central order. Other scientists have also expressed this concern, and we have spoken of the authority that must be accorded them. What is compelling, then, is the new era of qualitative science that is now quietly unfolding out of that quantitative science. That it is 'unfolding' is important to remember: the qualitative science that is slowly emerging has not come about through a repulsion of quantitative science; on the contrary, the best work is that which is faithful to it, as Heisenberg predicted. Recall that it was the use of the "dull and disappointing" method that uncovered the intellectual symmetries that Heisenberg believes are the ground of physical existence, and it must be added that it was firm adherence to this approach that allowed this discovery; it was by asking about the energy transitions of EPs (rather than what they are or look like) that Heisenberg was led to an understanding of the essential nature of an EP.

Qualities through quantities, and this, it seems, through a concern for the wider connections.

It is interesting, then, that this emerging qualitative science seems to be taking the form suggested by Heisenberg, that is, where phenomena exist which cannot be captured by the concepts of a particular idealization - again, that regard for the broader connections. Creativity, as we have mentioned, does not fit into the notion of a clockwork universe, and so entirely new areas of inquiry have opened up. As another illustration, recall that Heisenberg used the example of "life" as something that would urge a partnership of physics and biology forward in dialogue to new understanding. In time, this will no doubt take science to levels investigating love, morals, and meaning: but this "science" will not be recognizable as the science of yesterday, and Heisenberg did realize that the forms of the science he loved would one day pass away. Furthermore, as Heisenberg suggested, the forms will change with the content; so although it appears that the qualitative science of the future might somehow resemble the forms of contemporary religion, the route it takes to reach the levels mentioned above will not simply lead to the same insights religion has thus far come to. In a true and sober dialogic unfolding, <u>new</u> understanding is achieved, a new facet of our relationship to the central order is revealed. But a great deal of work will be necessary to reach this qualitative

science, perhaps much more work and thought than even the complex world of Newtonian and quantum science has required.

It is not surprising that the expression of this new spirit, as it is manifesting itself in, for example, the study of religion/philosophy, requires a great deal of effort on the part of those involved. It is as if people are fighting to see something so huge, so immense, that they must cast about in all directions to grasp it. An early example is found in Huxley's The Perennial Philosophy, which moved from tradition to tradition, seeking, hoping to evoke this nameless vision; certainly, his own experiments with the doors of perception suggest a new willingness to seize upon reality with all that is given to us. As another example out of many, one thinks of Erazim Kohak's attempts to "evoke a vision" rather than argue a point, to have one 'see, feel, and sense' the eternal, rather than speculate about it. Perhaps more to Heisenberg's taste (though he would have, I believe, been affected by Kohak's book) might be the work of Hans-Georg Gadamer. Surely, though their aims are different, there is some profound connection between Gadamer's concerns and Heisenberg's, and the way in which they approach that concern. Nonetheless, all the forms illustrated above are connected by their concern for the broader connections, for the human relation with the central order. What is interesting for us is that they can all be enclosed in that vast Platonic tradition, which, as it unfolds with the new spirit, may well prove to be the most

appropriate form in which to grasp this renewed concern with the central order. It is open to dialogue, to questions, to new avenues of understanding and discussion; it is multi-levelled and multi-faceted.

Finally, this same spirit, this concern for the broader connections and the relation to the central order can also be observed in the surfacing efforts at interreligious dialogue, the more fruitful of which occur at perhaps the highest level of that tradition, the level of genuine linkage to the central order, however that is understood. Of course, interreligious dialogue has always existed - doubtless it is natural at that highest level to want to discover those new facets of relationship found through other forms, through other traditions. However, there is today a conscious and growing movement to this, one that is much more than simply an interest in comparative religions. Not surprisingly, this particular endeavour, more than all the others, requires of the dialogue partners precisely what Heisenberg suggests, and nothing less: utter devotion, careful work and attention to detail. The form is as crucial as the content. Hence the work involved: not only must one be fully aware of the forms of one's own tradition (for how else could one have reached the highest levels of understanding if not by working through those forms?), but one must, as far as possible, understand and experience the forms of the other. Genuine devotion is indispensible, as Heisenberg has emphasized time and again.

There is no true understanding without it. It is difficult work; however, it is important that the broader connections be explored, and these devoted efforts speak of that new spirit of the time, one which has as its concern our relation to the central order, a uniquely-understood relation, gleaned from all the wisdom that humanity can offer. No one yet knows what this understanding may be - it is still unfolding. But it affects us even as it unfolds - understanding is achieved as much by working through the avenues, through the forms, as it is by viewing the structure complete.

I suspect that Heisenberg will play a large part in this unfolding, simply because his total religious understanding was so profound. Like a genuine participant of interreligious dialogue, he perceived in depth the forms and content of both his scientific and religious traditions, the latter forms being the artistic and ethical; his experiential and intellectual perception enabled him, through dialogue, to achieve new and significant insight. Heisenberg does not claim to have the final word, a claim which would only cloud that translucent splendour of the one. Rather, he offers his insights to the world, in the hopes of further clarity. This work simply re-presents - re-offers - that insight, that vision, in order that true dialogue with Heisenberg can begin. If we desire to find our way back to the centre, and we certainly need to, then we cannot ignore it.

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