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## CREATIVE SELF-CRITICISM IN SCIENCE AND IN ART

My work is concerned mainly with an abstract subject: the problem of human knowledge and, in particular, of scientific knowledge.

I am an optimist. I am an optimist in a world where among the intelligentsia it has become a strict rule that one must be a pessimist if one wants to be "in". But I do believe that our age is not so bad as is generally maintained; I do believe that it is better and more beautiful than its reputation. A quarter of a century ago, I gave a lecture, the title of which sounds today even more provocative than it did then: "The History of our Time: An Optimist's View".

For many—at least since the time of Adolf Loos and Karl Kraus, both of whom I knew—our intellectuals have strictly adhered to the principle that our so-called culture is a commercialized industry, and therefore just kitsch and vulgarity. Especially in what this industry offers to the masses as culture, the pessimist sees nothing but depravity and tastelessness. But an optimist also sees the other side: millions of records and tapes of the most beautiful works by Bach, Mozart, Beethoven, and Schubert—the greatest musicians of all—are being bought; and the number of people who

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have come to love these great musicians and their wonderful music has become incalculable.

Of course I must agree with the pessimists when they point out that we almost deliberately educate our children to become accustomed to cruelty and violence by exposing them to cruel and violent films and television. Unfortunately almost the same holds for modern literature. As an optimist, however, I can say that in spite of all our attempts to propagate violence, there are still many good and helpful people in the world. And in spite of everything the cultural pessimists have to say about the hatefulness of our time—and sometimes it is quite convincing—there are still many people who are happy to be alive.

The pessimists point to the moral and political decline, to the disregard for human rights which we all thought secure. They are right. But are they also right when they blame this on science and its use in technology? Certainly not. And the optimist remarks that science and technology have brought modest prosperity to the peoples of Europe and America and that the appalling poverty and the suffering of the previous century have almost been banished from large areas of the world.

I am not a believer in progress or in a law of progress. In the history of mankind there are ups and downs. Great wealth can concur with great depravity, and a flowering of the arts may concur with a decline of humanity and of good will. More than forty years ago I wrote a few things against the belief in progress and against the influence of fashions and the cult of modernity upon art and upon science. Only quite recently we were called upon to believe in the idea of modernity and of progress and today we are to be injected with cultural pessimism. What I want to say to the pessimists is that, in my long life, I have seen not only retrogression but also very clear evidence of progress. The cultural pessimists who do not want to admit that there is anything good about our age and our society are blind to this, and they make others blind. I believe that it is harmful when leading and admired intellectuals continually tell people that they are in fact living in hell. In this way they make people not only dissatisfied—that would not be so very bad—but they make them also unhappy. Their joy in living is taken away from them. How did Beethoven who in his personal life was deeply unhappy, end his work? With Schiller's *Ode to Joy*.

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Beethoven lived in a time of disappointed hopes of freedom. The French Revolution had perished in a reign of terror and in the Empire of Napoleon. Metternich's Restoration suppressed the idea of democracy and sharpened class antagonism. The misery of the masses was terrible. Beethoven's *Hymn to Joy* is a passionate protest against the class antagonism by which mankind is divided; "sharply divided" (*"streng geteilt"*), says Schiller. Beethoven alters these words in one place, for an outburst by the choir, writing: "insolently divided" (*"frech geteilt"*). Yet he knows no class hatred: he knows only the love of his fellow men. And almost all his works end either in a spirit of solace, as does the *Missa Solemnis*, or jubilant, as do the symphonies and *Fidelio*.

Many of our contemporary productive artists have become victims of pessimistic propaganda about our culture. They believe that it is their task to present what they regard as a gruesome world or a gruesome historical period in a gruesome manner. It is true that even some great artists of the past did just this. I am thinking of Goya or Käthe Kollwitz. Such criticism of society is necessary, and it should be deeply disturbing. But its significance should not lie in lament; rather, it should be a call to overcome suffering, as in *The Marriage of Figaro* which is packed with criticism of its period. It is full of wit, satire, and irony; but it also contains a deeper significance. There is plenty of seriousness and even grief in this great work, but also much joy and overflowing vitality. The theme of my article, "Creative Self-criticism in Science and in Art", is closely related to what I said in my introduction. Even though only briefly, I should like to speak about some of the similarities and differences between the creative work of the great natural scientists and that of the great artists, partly in the hope of combatting the propaganda of the cultural pessimists against the natural sciences, an issue that has recently become topical.

Great artists always have one central interest: their work; the work on which they are engaged. That is the meaning of the saying "Art for art's sake": for this means: art for the sake of the *work of art*. But the same is true of the great scientists. It is quite wrong to think that the inducement for doing natural science lies in its applications. Neither Planck nor Einstein, neither Rutherford nor Bohr, thought of a possible application of the atomic theory. On the contrary, until 1939 they thought that any such application was

impossible; they relegated the idea to the realm of science fiction. These men were searching for the sake of the search; seeking the truth for its own sake. They were physicists, or, perhaps better, cosmologists, inspired by the desire that Goethe's Faust expresses when he says:

"To know what forces there might be  
That hold this world in unity".

This is an ancient dream of mankind, a dream of poets and of thinkers. Cosmological speculation can be found in all the ancient civilizations. It is found in Homer's *Iliad* (8, 13-16) and in Hesiod's *Theogony* (720-725).

There are still some scientists and of course many amateurs who believe that the natural sciences just collect facts—perhaps in order to make use of them in industry. I see science differently. Its beginnings are to be found in poetical and religious myths, in human fantasy that tries to give an explanation of ourselves and of our world. Science develops from myth, under the challenge of rational criticism, a form of criticism that is inspired by the idea of truth; by the search for truth and by the hope of attaining it. The basic questions underlying this criticism are: Can this be true? And is it true? Thus I come to the first thesis of my address: poetry and science have the same origin. They originate in myths.

My second thesis is as follows: we can distinguish two kinds of criticism, one that has aesthetic and literary interests and one that has rational interests. The first leads from myth to poetry, the second leads from myth to science; or to be more precise, to natural science. The former evaluates the beauty of the language, the energy of the rhythm, the radiance and vividness of the images; the dramatic tension and its persuasive power. This kind of critical judgement leads to poetry, especially to epic and dramatic poetry; to poetic song, and with it to classical music.

Rational criticism, by contrast, asks whether the mythical report is true; whether the world really evolved in the manner asserted; whether it could have been created as Hesiod tells us or, perhaps, in accordance with *Genesis*. Under the pressure of such questions myth becomes cosmology, the science of our world, of our environment; it turns into natural science.

My third thesis is that there are still many traces left over from the common origin of poetry and music on the one hand and of

cosmology and science on the other. I am not asserting that all poetry is mythical in character, or that all science is cosmology. But what I wish to say is that in poetry—one only has to think of Hofmannsthal's *Jedermann*—and in science, the creation of myths still play an unexpectedly large role. Myths are our attempts, naive and inspired by our imagination, to explain ourselves and our world to ourselves. A large part not only of poetry but also of science can still be described as a naive attempt, inspired by imagination, at explaining our world to ourselves.

Poetry and science—and therefore also music—are blood relations. They stem from the attempt to understand our origin and our fate, and the origin and the fate of our world.

These three theses can be described as historical hypotheses, although for Greek poetry, especially for Greek tragedy, the mythical source can hardly be doubted. For the enquiry into the beginnings of Greek natural philosophy, the three hypotheses have shown their fruitfulness. Our western natural science and our western art are both the rebirth—the renaissance—of their Greek predecessors. Yet although art and science have a common origin, there are of course essential differences between them.

In science there is progress. That has to do with the fact that science has an aim. Science is the search for truth and its aim is pursued for some length of time. One can indeed sometimes talk about progress in art. For a long time, the imitation of nature was an aim in painting and in sculpture; although it was certainly never their only aim. And indeed we can speak of progress relative to this aim, for instance in the treatment of light and shade. Perspective can also be mentioned here. But aims like this were never the only driving forces in art. Great works of art often affect us quite independently of the artist's mastery of such skills and other means that are subject to progress.

It has often been seen and has often been emphasized that there is no general progress in art. Primitivism has perhaps over-emphasized this fact. Yet where there certainly is progress, and of course also decline, is in the creative power of the individual artist.

Every artist has to learn his art, even an incredible genius like Mozart. Every artist, or nearly every artist, has his teacher; and every great artist learns from his own experiences, from his own

work. Oscar Wilde says: "Experience is the name everyone gives to their mistakes". And John Archibald Wheeler, a great physicist and cosmologist says: "Our whole problem is to make the mistakes as fast as possible". My own comment on this is: And it is our task to discover our mistakes, and to learn from them. Even Mozart made radical changes and improvements to some of his works, for example to an early work of his, the first string quintet in B flat major. Mozart's greatest works were produced in the last decade of his short life, from about 1780 to his death in 1791, between the ages of 24 and 35. This shows indeed that he must have learnt through self-criticism, and astonishingly quickly. It is still quite incredible that he wrote the *Seraglio* at the age of 25 or 26, and *Figaro* at the age of thirty.

Yet the title of my present address, "Creative Self-criticism in Science and in Art" was inspired by the work of Beethoven; more precisely, it was inspired by an exhibition of Beethoven's sketch books, organized by the *Gesellschaft der Musikfreunde* (Society of the Friends of Music) in Vienna; an exhibition which I visited many years ago.

Beethoven's sketch books are documents of this creative self-criticism; of his constant reconsideration of his ideas, and of the often relentless corrections which he made to them. This attitude, an attitude of ruthless self-criticism, makes it perhaps a little easier to comprehend Beethoven's astonishing personal development, from the time he began composing, influenced by Haydn and Mozart, to his last works.

There are different kinds of artists and of writers. Some do not seem to work with the method of error elimination. They are, it seems, capable of creating a perfect work, without any preliminary attempts; they achieve perfection immediately. Amongst philosophers, Bertrand Russell was a genius of this kind. He wrote the most beautiful English; and in his manuscripts there was perhaps just one single word changed, in three pages, or perhaps in four pages. Others work in a totally different way. Their method of writing is the method of trial and error, the method of making mistakes and of correcting them.

Mozart belonged to the first group of creative artists, it seems, although he rewrote some of his works. But Beethoven certainly belonged to the second, to those whose work sometimes grows out

of many corrections.

It is of interest to contemplate the methods of work adopted by these artists who belong to the second group. I should like to stress that everything I say about this is speculative and conjectural. I conjecture that these artists start with a problem, or a task; for example with the task of writing a violin concerto or a mass or an opera. I suppose that it is part of the task to have some idea about the size of the work, its character and its structure—say, its sonata form—and perhaps also about some of the themes to be used. Or the plan may be much more detailed, especially in the case of a mass or an opera.

Yet when it comes to the execution, to actual work, to the realization of the idea and to transferring it onto paper, then even the artist's plan begins to change under the influence of the execution of his work, which embodies his self-critical corrections and the elimination of errors. The plan becomes more concrete, its outlines become more definite. Each part, each detail, is judged as to whether or not it fits in with the ideal picture of the whole. And *vice versa*: the ideal picture of the whole is constantly corrected as the work proceeds to be realized in its details. There is a feedback effect here, a give and take between the plan, the ideal picture, as it becomes clearer and more definite on the one hand, and on the other the emerging concrete work, in the process of being completed through the correction of errors.

All this can perhaps be seen most clearly in the case of a painter working on a portrait; that is, in the case of an artist who tries to build up his interpretation of a natural object. He plans, he sketches, he starts to correct. Here he adds a speck of colour and stands back to test the effect. The effect of the added speck of colour greatly depends on the context, on everything which is already there. And, *vice versa*, the new speck of colour in its turn affects the whole. Everything is changed by it, everything becomes different, better or worse. And with the effect on the whole, the ideal picture at which he aims, and which is never quite fixed in his mind, is also changed. And in the particular case of the painter of portraits, the likeness that the artist tries to attain, and his interpretation of the character of the subject, are also changing.

The important thing here is that the act of painting, that is, an attempt at realization, must of course come before any act of

critical comparison and of correction. ("Making comes before matching", says Gombrich). On the other hand there must be an idea, approaching an ideal picture, with which the artist can compare the work so far achieved, since anything like a correction is only made possible by a comparison with such an ideal object. When, in the particular case of the painter of portraits, an object to be represented is present to the artist, then, the problem may be somewhat less pressing. It is probably similar in music where self-criticism and the correction of errors may be easier if a text is to be set to music. In any case, the correction of errors is like a comparison, a comparison between what has been achieved and what is being aimed at, the ideal picture of the work which is continuously changing under the impact of the work actually done. The work that has been done influences the creative process more and more powerfully. In the case of a great work this can go so far that the artist who wrote it can hardly recognize it any longer as his own work. It has become greater than his conception. This happened with Haydn's *Creation* and, in a completely different way, with the symphony that Schubert himself abandoned: the *Unfinished*.

Let me now turn in conclusion to a comparison of the arts with the sciences which are maligned rather than understood by the cultural pessimist. In science the work is the hypothesis, the theory; and the aim of the activity is truth, or approximation to the truth, and explanatory power. This aim is largely constant; and this is the reason why there is progress. It is a progress that can last for centuries: the progress towards ever better theories. In art, the most important criticism is the creative self-criticism of the artist; in science however, criticism is not just self-criticism but also co-operative criticism: when, a scientist overlooks a mistake or tries to conceal it—something that fortunately happens only rarely—this mistake is as a rule discovered by other scientists. For the method of science is self-criticism and mutual criticism. The criticism judges the theory by its attainments in the search for truth. It is that that makes the criticism rational.

The theory, that is to say, the work of the creative scientist, has therefore much in common with the work of art; the creative activity of the scientist resembles that of the artist—at least the activity of those artists to whom Beethoven belonged, those artists

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who begin with a bold conception and who can raise their work by means of creative criticism to heights unthought of; so that, as a result, the beautiful *Choral Fantasia* grows into the *Ode to Joy*.

In science, the great theoretician corresponds to the great artist, and, like the artist, he is guided by his imagination, his intuition and his sense of form. Einstein said of the model of the atom developed by Niels Bohr in 1913—a revolutionary theory that was soon afterwards greatly improved—that it was a work of the “greatest musicality”. Yet in contrast to a great work of art, the great theory always remains subject to further improvement.

The scientist knows this and he also knows that his imagination, his intuition, and even his sense of form lead him more often astray than to his aim; that is, to a better approximation to the truth. This is why, in science, a permanent critical examination not only by the creator of a theory but also by other scientists is essential. In science there is no great work based merely on inspiration and a sense of form.

I want to close with a quotation from one of the greatest of scientists, Johannes Kepler, the great cosmologist and astronomer who died in the year 1630, the twelfth year of the Thirty Years War. In this quotation, Kepler takes as his starting point his theory of the movement of heavenly bodies, and he compares it to music, especially to the divine music of the spheres. Yet almost unintentionally, Kepler concludes with a hymn of praise to the music created by man, to the polyphonic music that was then still a fairly recent discovery. Kepler writes:

“Thus the heavenly motions are nothing but a kind of perennial concert, rational rather than audible or vocal. They move through the tension of dissonances which are like syncopations or suspensions with their resolutions (by which men imitate the corresponding dissonances of nature), reaching secure and pre-determined closures, each containing six terms like a chord consisting of six voices. And by these marks they distinguish and articulate the immensity of time. Thus there is no marvel greater or more sublime than the rules of singing in harmony together in several parts, unknown to the ancients but at last discovered by man, the ape of his Creator; so that, through the skilful symphony

of many voices, he should actually conjure up in a short part of an hour the vision of the world’s total perpetuity in time; and that, in the sweetest sense of bliss enjoyed through Music, the echo of God, he should almost reach the contentment which God the Maker has in His Own works”.

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