

Scientific Center of the Polish Academy of Sciences in Paris

1

**science**  
and  
**society**

Warsaw – Paris 2000

# SCIENCE, SOCIETY AND HOPES OF A RENAISSANCE UTOPIST<sup>1</sup>

Achim MÜLLER \*

*"The end of our foundation is the knowledge of causes, and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible". F. Bacon [1]*

The related problem: In modern society with its decentralized structures and extreme inter-related and inter-dependent network of social sub-systems on one hand, and the ever-increasing insatiable urge of the individual for prosperity and freedom (including the related pressures involved) on the other, simple, satisfying remedies for non-predictable possible burdening post-problems through attempting to fulfill Bacon's programme – believing in a linear cause relationship – cannot be found. The effects of (massive) intervention (in the sense of Bacon) in a complex network system<sup>2</sup> such as today's society are often chain-reactions (including feed-back) and therefore cannot be understood on the basis of the linear causal nexus (*causa aequat effectum*), and are consequently also not predictable.

---

\* Department of Inorganic Chemistry, Faculty of Chemistry University of Bielefeld, Germany. Professor of Chemistry, Foreign Member of the Polish Academy of Sciences, Member of the Leopoldina Academy, Member of the Academia Europaea, Titular Member of the European Academy of Sciences, Arts and Humanities (Paris).

<sup>1</sup> This paper is an extended version of a lecture presented at the University of Wrocław, Poland, 14th November 1997.

<sup>2</sup> The system of all known and unknown chemical substances can be taken as simple model since all elements are *potentially* inter-connected ("verschränkt" in the sense of Schrödinger; see [2]). Each interaction between two elements of a network system changes the quality of the whole system.

## INTRODUCTION

Since science has tremendously influenced modern *Western Society*, a fact which has not always been acknowledged, it seems appropriate to consider whether the hopes and dreams of earlier thinkers in this context have at least partly been fulfilled. The real value of a society can be judged according to the extent of importance it attaches to the cultivation of science and education, or generally speaking culture. In principle, this statement includes the assumption that, should a member of this society come into urgent need, the society should be in a position to offer an optimal provision, both mentally and physically. Since this problem is global – and will probably remain so in every age – and remedies for the future cannot be guaranteed, it seems worthwhile to recall from time to time the scientific programme of the Renaissance utopist Francis Bacon [3, 4], who together with Descartes and Galilei, can undoubtedly be regarded as the founders of modern science.

Utopian dreams about an ideal society are as old as mankind. Their fascination stems from man's innermost endeavour to establish a more desirable society and ideal conditions where his slumbering powers and creative instincts can be awakened to achieve a better lot for man's life on earth. The slow but dramatic transition from Medieval patterns to the open world of the 16th and 17th century, furthermore, presented for Europe a turbulent time and an age of strong contrasts. Thus, it is not surprising that the Renaissance period brought forth the appearance of several utopias, the most important being Bacon's *New Atlantis*, More's *Utopia* (1516) showing a woodcut map of Utopia on the cover, and Campanella's *Civitas Solis* (1623) (for some related literature see [5]).

Considering the present European crisis in educational and research institutions (which in Germany over the past 30 years have been continuously subjected to the disastrous experimentation of politicians), a recollection of Bacon's programme seems to be particularly relevant. The question is to what extent scientific knowledge, i.e. achieved by scientists, has an influence on the structure of a society or on its dynamics, which means the development of civilization, a topic which leads to our main concern, the optimal structure of the institutions that generate knowledge. Not only the profits and security offered by acquired scientific knowledge (in the sense of Bacon) are of importance for society but also the pursuance and advancement of learning without emphasis on utility factors. In the Western World science (and especially research results from Chemistry<sup>3</sup>) was and still

---

<sup>3</sup> In this context, it is interesting to read in P. Ball's book *Designing the Molecular World: Chemistry at the Frontier* (Princeton University Press, Princeton, New Jersey, 1994): „Some of the most exciting scientific developments in recent years have come not from theoretical physicists, astronomers, or molecular biologists but instead from the

is responsible for the high-standard living conditions of the individual which range from material to non-material aspects but which have concomitantly led to the emergence of further problems due to the newly gained freedom without the need to fight or struggle for the basis of an existence, as was necessary in former times. (Unfortunately, too few people think about the reasons for their high standard of living.) Thus science, consequently, has the delegation to deal with the very different kinds of burdening post-problems arising in society, which are extremely complex and, in addition, not predictable in any way.

In short, on the grounds of high-standard basic research, science should always be prepared for present, unexpected global eventualities and at least strive to be prepared for future unpredictable post-problems due to all types of former anthropogenic intervention.

## FRANCIS BACON

Francis Bacon (1561-1626) [3], the author of the *Instauratio Magna*<sup>4</sup> with its anti-Aristotelean part *Novum Organum*, was an English philosopher, scientific methodologist, essayist, and politician. Bacon rose to the position of Lord Chancellor of England but was forced to retire in 1621 after conviction of bribery in his official capacity as judge. He started writing his utopia *New Atlantis*, which is still worthwhile recalling, rather late in life in his country house at St. Albans. This work written around 1623 is a formally incomplete work which was published posthumously in 1627. The primary motive of his intellectual life was the reformation of learning and of the scientific research methods of his time with the hope of establishing a new conception of the goals of human knowledge. Bacon saw the scientist as occupying a superior position in society.

## NEW ATLANTIS

In the fragment [1] Bacon attempts to outline a type of ideal state, similar in principle to that of Plato, but which is secured by the ever-increasing results of experimental science (see for example [4]).

---

chemistry lab. Chemists have created superconducting ceramics for brain scanners, designed liquid crystal flat screens for televisions and watch displays, and made fabrics that change color while you wear them. They have fashioned metals from plastics, drugs from crude oil, and have pinpointed the chemical pollutants affecting our atmosphere and are now searching for remedies for the imperiled planet".

<sup>4</sup> The main work (incomplete) of Bacon, *the Instauratio Magna* comprises six parts including *The Advancement of Learning* (Vol. 1) and *Novum organum* (Vol. 2).

The first part of the fable describes a ship on its journey to unexplored regions and is typical for the utopian travel-reports-literature of the time. After landing on the shores of the utopian island New Atlantis, the structure of society is explained to the travellers by one of the island representatives. The ideal commonwealth can be characterized as politically and socially conservative, imitating the hierarchical organization in contemporary England. Important for us is that society supported the scientific institution Salomon's House (see below), in providing the ideal social conditions necessary for the promotion of scientific experiments, which in turn supported society through scientific progress or novel technological devices.

*New Atlantis* is not so much a social utopia whereby the real importance comes to light in the last section dealing with scientific knowledge or applied science and shows Bacon's life-long passion for scientific experiments. In this section Bacon attempts to describe how his scientific research programme, also outlined in some parts of the *Instauratio Magna*, could be imagined or function in practice. The intellectual and structural setting for his programme was provided by the *House of Salomon* or the *College of the Six Days' Works*. The aim of this institute was [...] *the knowledge of causes, and secret motions of things; [...], to the effecting of all things possible*, of course an utopian dream.

The *House of Salomon* was elaborately equipped for the purpose of scientific research in very different fields like chemistry, geochemistry, biochemistry, meteorology, and medicine, just to use related modern terms. Bacon describes not only a panoramic spectrum of scientific possibilities and laboratory facilities in an institute but also an interdisciplinary collaboration resembling today's so-called team-work which would undoubtedly quicken the hearts of many scientific researchers today. According to the message of the representative, some members of the scientific community were secretly sent abroad every twelve years to acquire a knowledge of foreign progress in technological fields, others explored the literature in search of novel discoveries and latest scientific results, while the others were responsible for scientific experiments. The scientists had the power to select what scientific information should be passed on to the state as also what results were suitable for publication. They decided even on the authenticity of miracles. Salomon's House was similar to a state within a state using the acquired information for the welfare of the whole population. Its autonomy is the striking element of this utopia. Science was to be remote to, or absolutely free from any form of external pressure, since the expectations and demands of a society concerning science, and thus its own welfare, could not otherwise be optimally fulfilled, nor could the creative genius of the scientific investigators be developed to the full.

Bacon is not primarily concerned with the beauty of nature but rather with the fascination and scientific experiment of her phenomena. He was not only interested in providing necessities but also, or in particular, in achieving luxury: The production of exotic fruits, excellent foods, drinks, perfumes and even precious stones, to mention but a few. The bright colours, the splendid costumes, and grandeur of officials and of public ceremonies symbolize Bacon's idea of luxury, too.

For the promotion of his programme, Bacon is concerned with the education of scientific experts, or a scientific elite and not directly with the transmission of knowledge to society. He deals with what can be discovered, and in particular with how things can be discovered. The acquired knowledge is subsequently passed on to society in the form of novel useful technology (see also [5d]). In any case, what Bacon could not realize at that time were the long-term post-problems resulting from preliminary intervention in the form of assistance.

#### RESPONSE TO BACON'S IDEAS<sup>5, 6</sup>

The Baconian faith in scientific knowledge was praised by Kant for its foresight and progressiveness. The 2<sup>nd</sup> edition of his *Critique of Pure Reason* for example, bears as a motto [...] *infiniti erroris finis et terminus legitimus* [...] conclusion and true termination of an endless misunderstanding) [6], a phrase taken from Bacon's *Instauratio Magna*. He was praised by E. Bloch for his *Naturweisheit* (wisdom concerning nature) who stated that *entgegen der landläufigen Meinung (ist Bacon) weder ein purer Utilitarier noch ein purer Empirist* (contrary to the generally accepted opinion, (Bacon is) neither a pure utilitarian nor a pure empiricist) [7]. But strangely enough he was sharply criticized by Justus von Liebig (the danger of pure utilitarianism) [8] and, as not otherwise expected, by Horkheimer and Adorno who maintained that *Das unfruchtbare Glück aus Erkenntnis ist lasziv für Bacon [...]* (The infertile happiness of knowledge is lascivious according to Bacon [...]) [9, 3c].

<sup>5</sup> Bacon's idea of the ideal institution for the purposes of research in natural sciences anticipated the foundation of scientific academies some fifty years later. The oldest German academy for instance, the *Academia Naturae Curiosorum*, later called the *Sacri Romani Imperii Academia Caesareo-Leopoldina Naturae Curiosorum* by Leopold I (1687), and now known as the *Deutsche Akademie der Naturforscher Leopoldina* was founded in 1652 in Schweinfurt under the motto „The exploration of Nature for the benefit of mankind”, a basic idea of Bacon (see [5i]).

<sup>6</sup> D'Alembert regarded Bacon as the greatest and most universal philosopher and, together with Diderot, adopted Bacon's classification of sciences as appropriate basis for their *Encyclopédie* (see [1], p. XIV and [15]). The *Encyclopédie* is also referred to in section VI.

What significance does Bacon's work bear for science today, referring metaphorically to the ship of his *Instauratio Magna*? In what direction is his ship, which is now ours, currently sailing? On the title page of his *Novum Organum*, which is a part of his *Instauratio Magna*, Bacon metaphorically shows the ship of science on sail with unknown destination but with the hope of reaching an utopian promised land that was to be ruled by science and was to reveal explanations for nature's hidden secrets.

### BACON'S MESSAGE AND RELEVANCE FOR PRESENT AND FUTURE PROBLEMS

Although scientists in most European countries have been guaranteed by law an intellectual freedom like the members of the *House of Salomon* with respect to scientific research, there is always a danger that this independence could in principle be rescinded in time to come, a fact which should continuously force scientists to critical discussion of the problems relating Science and Society. Gernot Böhme, a German philosopher, in the book entitled *Wissenschaft und Gesellschaft* ("Science and Society") [10] discusses corresponding problems in his contribution and argues that what we have achieved today is the realization of Bacon's programme (*Salomon's House is Reality*) but without the Baconian beliefs. But is this statement correct? Has Bacon's programme actually been realized or can it ever be realized?

A related basic question is: Is it possible to make a prediction as to whether a functioning system of society like that of science, perhaps in the sense of Luhmann [11], can remain stable? Definitely not, as not only the complexity of scientific institutions and their complex interaction with society, but also the enormous pressure involved in reacting correctly to unforeseeable problems, renders a prediction in the form of generalizations and simplifications absolutely impossible<sup>7</sup>. To pick out just two examples, the unexpected appearance of a virus in humans, which has a high mutation rate and a structural protein segment which is complementary to a receptor of a cell of the human immune system has revolutionized to some extent the *scientific community*. More than ten thousand scientists are currently pursuing an explanation of the pathobiochemical secrets surrounding the HIV infection. As a second example (unforeseeable) the epidemic of BSE-type diseases in connection with related novel and unexpected type of infection (the so-called

<sup>7</sup> This corresponds to Popper's statement that social developments, in principle, are not predictable (K. R. Popper, *Das Elend des Historizismus*, Mohr, Tübingen, 1969, p. XI).

prion problem) may be mentioned. Moreover, it is even in principle possible that hitherto unknown procaryotes (wild-type or mutants of these) or viruses will be able to gain superiority over the human population. A modern type of *Salomon's House* should, to some extent, be man's endeavour for the requirements of modern society. The individual scientists, those of the *Salomon's House* type, should always be able to adapt their research to the current, changing and unpredictable circumstances of the outside world of the homo sapiens. But a condition for this is that basic research is continuously pursued on an extremely high level so that the high-level basic knowledge of the scientist enables him to react with best-possible (in all cases definitely not perfect) solutions to unpredictable problems not known today.

This statement is also of importance since each new type of help or each increase in the living standard of human beings in the sense of Bacon represents intervention in the larger, more complex system, society. This act of assistance leads often, if not necessarily, to the creation of future encumbering post-problems which are not predictable and correspondingly require the constant "reparation and annexation" of *Salomon's House*, a fact which is currently of particular relevance. Perhaps even the use of the drug *Viagra* will change society.

The basic condition for the complete fulfillment of Bacon's utopian programme is not provided, nor will it ever be provided. Generally speaking a complex system in a stationary non-equilibrium state is sensitive to all types of intervention. In this sense, Böhme is not correct, as Bacon's programme ([1a], p. 288) is not fulfilled now and furthermore will always be an utopia.

In a separate publication, Böhme et al. [12] have argued that since science is open to external purposes, for example to economical and political purposes, these external factors necessarily become the guidelines for the development of our scientific theories. According to the authors, the phase transition to that kind of structure of science represents the *Finalization of Science*<sup>8</sup>, probably they mean in an

---

<sup>8</sup> This was severely criticized by Luhmann ([11], p. 621): „Insofern war auch die Diskussion über eine gesellschaftliche ‚Finalisierung‘ der Wissenschaft schon vom Konzept her verfehlt. An die Stelle dieses Konzepts haben wir die Vorstellung der rekursiv geschlossenen, autopoietischen Autonomie gesetzt. Sie besagt, daß die Teilsystem-qualität der Funktionssysteme nicht auf einer Spezifikation gesellschaftlicher Kopplungen im Hinblick auf bestimmte Leistungserwartungen beruht, sondern gerade umgekehrt auf einer Abkopplung der Eigendynamik dieser Systeme von Bedingungen und Interessen ihrer gesellschaftlichen Umwelt. Dies läuft aber, wie gesagt, nicht auf einen Austritt aus der Gesellschaft hinaus. Die Teilsystemoperationen sind und bleiben gesellschaftliche Kommunikation. Sie sind, solange sie als Kommunikation durchgeführt werden können, immer auch gesellschaftlich angepaßt. Sie setzen auf vielfältige, direkte und indirekte (und oft sehr indirekte) Weise Gesellschaft auf einem Evolutionsniveau voraus, das funktionale Differenzierung ermöglicht“.



Aristotelean (*causa finalis*) sense. But this can only be true in part since man's Faustian instinct will also cause him to think and work independently, developing his own theories. The history of science has revealed numerous such events. Anyhow, generally speaking, the promotion of science, like scientific budgeting, should not be left to the entrustment of politicians whose actions are guided more by the ambition to survive the next elections rather than by the necessities of future developments and possible challenges of generations to come.

In this context, a further problem or question concerning aspects of the *Theory of Science* arises as to whether we will be able to reach an end-limit of our possibilities to increase basic knowledge, or to what extent have we already reached this limitation. J. Horgan in his new book *The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age* [13] claims that this limit has been achieved. This type of statement seems to be ridiculous and assumptions of a similar kind were made several times in the past: Even in the 16th century the Aristotelean firmly believed that his science knew all that could possibly be known, and to a certain extent all that remained to be done was clearing-up work or ordering. To give a further example: In about 1880 in Munich, the physicist von Jolly told the young Max Planck that it would make no sense to concentrate on physics since everything was already known.

Will the principal problems related to the origin and structure of the universe and the evolution of life, even if only referring for example to the fascinating problems regarding the evolution of the immune system<sup>9</sup> and of consciousness, ever be solved?<sup>10</sup> Or, more generally speaking, can we expect in the future an understanding of the evolution or the overall development in connection with the related potentiality of matter in the sense of Aristotle's concept pair *dynamis – energeia*? A further aspect is, as mentioned before, that each solution of an old problem raises new problems or questions not known beforehand.

## CONCLUSION: TIMELESS VALUES OF SCIENCE AND ETHICS?

As mentioned in the introduction, a society can be regarded as human with future perspectives only when science, in the sense of

<sup>9</sup> See for instance J. Stewart's article *Immunoglobulins did not arise in evolution to fight infection* in which he states: „However, invertebrates – from octopus to insect – have functionally effective systems of defence against invasion by bacteria and viruses. Nevertheless, the molecules involved are, structurally and evolutionarily, totally unrelated to immunoglobulins. So, do invertebrates have immune systems?“ [“Immunology Today”, 13 (No. 10) (1992) 396].

<sup>10</sup> Antinomies in the sense of Kant with respect to principal problems of cosmology and the structure of matter will always remain antinomies.

providing an increase in general knowledge, plays a leading role. Ideal circumstances would be if the educated, and those who aspire to knowledge were to hold a special rank in society, perhaps as supervisors for politicians, corresponding to Bacon's and to some extent to Plato's proposals. Education forms the basis and is a prerequisite for humanity in a complex society, for example today, where ethical principles have to be redefined and adapted in order to cope with burdening post-problems due to modernity or a high degree of civilization, such as those arising from the achievements, possibilities and also limits of modern medicine.

Aristotle and Kant, who did not restrict themselves only to details of our world, we have to consider, besides a very broad education, ethics as the base for society. In this context we should accept that, in contrast to C. P. Snow's viewpoint, we have only *One Culture*.<sup>11</sup> We should not tolerate at the universities *The Conflict of the Faculties*, as described by Kant in one of his latest works [16].

Let us conclude with Diderot's utopian declaration concerning the intention of his and d'Alembert's famous *Encyclopédie* [17]: *En effet, le but d'une encyclopédie est de rassembler les connaissances éparses sur la surface de la terre; d'en exposer le système général aux hommes avec qui nous vivons, & de le transmettre aux hommes qui viendront après nous; afin que les travaux des siècles passés n'aient pas été des travaux inutiles pour les siècles qui succéderont; que nos neveux, devenant plus instruits, deviennent en même temps plus vertueux & plus heureux, & que nous ne mourions pas sans avoir bienmérité du genre humain*<sup>12</sup> together with an important statement of Max Planck *Die absoluten Werte in Wissenschaft und Ethik sind es, denen zuzustreben die eigentliche Aufgabe eines jeden geistig regsamen Menschen ausmacht, eine Aufgabe, die immer wieder in der einen oder anderen Form, entsprechend der jeweiligen Forderung des Tages, an ihn herantritt. Daß sie niemals ein Ende findet, dafür sorgt das von manchen*

<sup>11</sup> This corresponds to our approach to interdisciplinary research (see for instance [14, 15]).

<sup>12</sup> *The aim [...] is to compile the knowledge scattered over the surface of the earth, to explain its system to the persons with whom we live and to those who will succeed us, that the labours of bygone centuries may not have been in vain, that our descendants become better and happier through becoming more wise, and we won't pass away without having accomplished a service for mankind.* Interesting is that Diderot in this context (*Encyclopédie*) cites a passage taken from Bacon: [...] *de impossibilitate ita statuo; ea omnia possible et praestabilia censenda, quae ab aliquibus perfici possint, licet non a quibusvis; et quae a multis conjunctim, licet non ab uno; et quae in successione saeculorum, licet non eodem aevo; et denique quae publica cura et sumptu, licet non opibus et industria singulorum.* (De Augmentis Scientiarum (1623), lib II, ch. i, p. 103; see also J. Spedding, R. L. Ellis, D. D. Heath (Eds.), *The Works of Francis Bacon*, Vol. I, Frommann/Holzboog, Stuttgart, 1963, p. 493 (Reprint of 1858 Issue).

*Scheinproblemen durchsetzte, aber auch stets echte Probleme in unaufhörlichem Wechsel schaffende, uns alle beständig zu neuer Arbeit rufende, werktätige Leben* [18]<sup>13</sup>.

Acknowledgement: The author thanks the Fonds der Chemischen Industrie for financial support.

## REFERENCES

- [1] (a) F. Bacon, *The Advancement of Learning and New Atlantis* (T. Case, Preface), Oxford Univ. Press, London, 1969, p. 288; (b) F. Bacon, *Neu-Atlantis* (J. Klein, Ed.; G. Bugge, Transl.), Reclam, Stuttgart, 1982, p. 43.
- [2] H. Primas, *Verschränkte Systeme und Komplementarität in: Moderne Naturphilosophie* (B. Kanitscheider, Ed.), Königshausen + Neumann, Würzburg, 1984, p. 243.
- [3] For literature about Bacon concerning the topic of this paper, see (a) C. Whitney, *Francis Bacon and Modernity*, Yale Univ. Press, New Haven, 1986; (*Francis Bacon: Die Begründung der Moderne* (H. Voges, Transl.), Fischer, Frankfurt a.M., 1989); (b) W. Krohn, *Francis Bacon*, Beck, München, 1987; (c) M. Peltonen (Ed.), *The Cambridge Companion to Bacon*, Cambridge Univ. Press, Cambridge, 1996.
- [4] (a) H. B. White, *Peace Among the Willows: The Political Philosophy of Francis Bacon*, Martinus Nijhoff, The Hague, 1968; (b) M. E. Prior, „Bacon's Man of Science“, *Journal of the History of Ideas*, 15 (1954) 348; (c) F. Tasche, G. P. Knapp, *Methodik und Intention: Zum Wissenschaftsbegriff von Francis Bacon*, *Zeitschrift für philosophische Forschung*, 25 (1971) 293.
- [5] (a) St. Thomas More, *Utopia* (E. Surtz S. J., Ed.), Yale Univ. Press, New Haven, 1964; (b) F. R. White (Introduction and Notes), *Famous Utopias of the Renaissance*, Hendricks House, New York, 1955; (c) J. K. Fuz, *Welfare Economics in English Utopias From Francis Bacon to Adam Smith*, Martinus Nijhoff, The Hague, 1952; (d) J. Bierman, *Science and Society in the New Atlantis and other Renaissance Utopias*, *PMLA*, 78 (1963) 492; (e) R. P. Adams, *The Social Responsibilities of Science in Utopia, New Atlantis and After*, *Journal of the History of Ideas*, 10 (1949) 374; (f) R. Ahrbeck, *Morus, Campanella, Bacon: Frühe Utopisten*, Pahl-Rugenstein, Köln, 1977; (g) K. Schilling, *Geschichte der Sozialen Ideen: Individuum, Gemeinschaft, Gesellschaft*, 2. Aufl., Kröner, Stuttgart, 1966; (h) W. Biesterfeld, *Die literarische Utopie*, Metzler, Stuttgart, 1974; (i) H. Minkowski, *Die Geistesgeschichtliche und die Literarische Nachfolge der Neu-Atlantis des Francis Bacon*, *Neophilologus*, 22 (1937) 120; *ibid* 185.
- [6] I. Kant, *Kritik der reinen Vernunft* („Critique of Pure Reason“) (R. Toman, Ed.), *Werke in sechs Bänden*, Bd. 2, Könenmann, Köln, 1995.
- [7] E. Bloch, *Das Prinzip Hoffnung*, 3 Vols., Chap. 37: „Bacon's Ars inveniendi“ (p. 758) and „Nova Atlantis, das utopische Laboratorium“ (p. 763), Suhrkamp, Frankfurt a.M., 1985.

<sup>13</sup> *The absolute values in science and ethics, to which each intellectually active human being aspires, are those which distinguish the real task, a task which again and again in one form or another confronts him in compliance with the respective demands of the day. That it never reaches its completion is ensured by the constant call to all to new achievements from our creative work in life, which is interspersed with many apparent problems but also always in permanent exchange with real problems.*

- [8] J. Liebig, *Über Francis Bacon von Verulam und die Methode der Naturforschung*, Literarisch-artistische Anstalt, München, 1863 (cited according to W. Krohn, [3b]).
- [9] M. Horkheimer, T. W. Adorno, *Dialectic of Enlightenment* (J. Cumming, Transl.), Seabury, New York, 1972; M. Horkheimer, T. W. Adorno, *Dialektik der Aufklärung*, Philosophische Fragmente, Fischer, Frankfurt a.M., 1971, p. 8.
- [10] G. Böhme *Am Ende des Baconischen Zeitalters* („At the End of the Baconian Age“) in „Wissenschaft und Gesellschaft“ („Science and Society“) (G. Gamm, G. Kimmerle, Eds.), Tübinger Beiträge zu Philosophie und Gesellschaftskritik, Vol. 3, edition diskord, Tübingen, 1991, p. 202.
- [11] N. Luhmann, *Die Wissenschaft der Gesellschaft*, Suhrkamp, Frankfurt a.M., 1990, p. 621.
- [12] G. Böhme, W. van den Daele, W. Krohn, *Finalization in Science*, Social Science Information, XV (1976) 307.
- [13] J. Horgan, *The End of Science. Facing the Limits of Knowledge in the Twilight of the Scientific Age*, Addison-Wesley, Reading, Massachusetts, 1996.
- [14] (a) A. Müller, A. Dress, F. Vögtle (Eds.), *From Simplicity to Complexity in Chemistry and Beyond*, Part I, Vieweg, Wiesbaden, 1996; (b) K. Mainzer, A. Müller, W. G. Saltzer (Eds.), *From Simplicity to Complexity*, Part II *Information – Interaction – Emergence*, Vieweg, Braunschweig, 1998.
- [15] A. Müller, *Supramolecular inorganic species: An expedition into a fascinating, rather unknown land mesoscopia with interdisciplinary expectations and discoveries*, Journal of Molecular Structure, 325 (1994) 13.
- [16] I. Kant, *Der Streit der Facultäten* („The Conflict of the Faculties“); vgl. z.B. Immanuel Kant, Werke in sechs Bänden, Bd. 6 *Der Streit der Facultäten und kleinere Abhandlungen* (R. Toman, Ed.), Könnemann, Köln, 1995.
- [17] D. Diderot, J. d'Alembert (Eds.), *Encyclopédie, ou Dictionnaire Raisonné des Sciences des Arts et des Métiers* (Diderot, Encyclopédie III, Lettres D-L), Hermann, Paris, 1976, p. 174.
- [18] Stimme der Wissenschaft, Geheimrat Max Planck, *Über die exakte Wissenschaft* Diskographische Dokumente, Akademische Verlagsgesellschaft, No. 15/4, Frankfurt a.M. (Recording: 1963).