Francia. Forschungen zur westeuropäischen Geschichte
Herausgegeben vom Deutschen Historischen Institut Paris
(Institut historique allemand)
Band 16 /2 (1989)

DOI: 10.11588/fr.1989.2.53560

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ANTI-MECHANISM, VITALISM AND THEIR POLITICAL IMPLICATIONS IN LATE ENLIGHTENED SCIENTIFIC THOUGHT

I

In 1786, the young Franz Baader proclaimed in his first book that the spell of the *Methodo scientifico-mathematica* had been broken throughout Europe[1]. As recently as forty years earlier, he asserted, scientists were still prone to consider physics as »virtually nothing else than applied mathematics«, an assumption that had led to the separation of chemistry from physics, which, in turn, had produced a dark, unfruitful period in the history of both sciences[2]. Now, a new epoch had dawned in which physicists and chemists had shed the burden of mechanist assumptions. Joined, again, they were cultivating the flowering fields of natural philosophy[3]. Eleven years earlier, the French physician, D. M. Roussel had advanced a similar claim about the life sciences in his popular book »Système physique et moral de la femme«[4]. The life sciences, he announced, had been revolutionized around the mid-century mark by men who had realized that the building erected by mechanism was threatening to topple. Rejecting the power of established authority, these medical men of Montpellier and Paris had placed the study of physiology, natural history, and anatomy upon totally different foundations[5].

These two statements, though made by relatively unknown writers of the time – one a young man just finished with his medical studies and about to begin studying mineralogy, the other a medical popularizer – were in no way unusual. Throughout Europe, thinkers in a host of disciplines demonstrated both a deep distrust for those who had made »our planet into a hydraulic machine« and an equally strong belief that a revised vision of natural philosophy

1 Franz Xaver Baader, Vom Wärmestoff, seine Verteilung, Bindung und Entbindung vorzüglich beim Brennen der Körper, Vienna and Leipzig 1786 p. 26.

2 Ibid. pp. 25–26. *In jenen spätern Zeiten, da der Aether allgemeine Mode worden, und die mechanische, nun mathematische Schule noch immer über der chemischen mehr die Oberhand gewann, so daß die Physik beinahe nichts als angewandte Mathematik war, und von ihrer Schwester, der Chemie getrennt, natürlich darben mußte; in diesen für beiede Wissenschaften keineswegs blühenden Zeiten suchte man die Meinung der Chemiker von einem eignen Wärmestoff zwar mit jener der mechanischen Schule, die das Wesen der Wärme in Bewegung sezte, zu vereinigen …; aber diese Vereinigung beider Lehrmeinungen fiel auch immer offenbar (wie man sieht) viel zu partheiisch zu Gunsten der leztern aus, und das natürlich, weil sie theils selbst meist von Mathematikern festgesetzt ward, und theils weil alles, was die Chemiker von den chemischen Eigenschaften ihres Feuerstoffes außer seinen sogenannten mechanischen, der Elastizität, Beweglichkeit u.d.g. zu sagen wußten, wirklich zu schwankend und unbestimmt war, als daß jene, dem beliebten Methodo scientifico-mathematica gemäß davon hätten Gebrauch machen können.*

3 Ibid., p. 128. The people whom he named as leaders in this endeavor were Cullen, Black, Irvine, Lavoisier, Kirwan, Elliot, Crawford, Priestly, Gmelin, and Bergmann.

4 I am using the German translation of Christian Friedrich Michaelis entitled »Physiologie des weiblichen Geschlechts«, Berlin 1786.

5 Ibid., pp. xiii–xv. The people Roussel cites as revolutionaries are Venel, Lamure, Barthez, Fouquet, Bordeu, Gardane, Robert, Roux, Vandermonde and especially Buffon.

was in the process of being formulated[6]. A new consensus about nature and science was being created, beginning around the mid-century mark and acquiring its definite form in the 1770's, which differed substantially from that which had been dominant at the beginning of the century. In effect, it proposed a different interpretation of nature and the ways to apprehend it, a new idea of the »order of things«. This shift was both widespread – influencing virtually all of the sciences – and central for late eighteenth-century perceptions, since most Enlightened thinkers subscribed to the imperative that life should imitate nature. This new »discourse of nature« necessarily engendered a host of redefinitions in those areas where nature or science served as guide or analogue for other forms of thought[7]. Hence, this often ignored shift in scientific sensibilities is central for any understanding of the dynamics of late Enlightened thought and aspirations[8]. Not only may it help us to understand the way in which life was perceived, it may – since science is a social product – allow us to extrapolate some of the political and social motives that characterized the age. Hence, what I propose to do in this essay is to describe the formation of this new language of nature, discuss its elaboration, and deal with the political and social impulses that this language both reflected and, equally important, to which it gave expression.

II

Though one could today trace the various influences that led to this reformulation – for example the spread and transformation of Leibnizian philosophy, the influence of Stahl, or that of the writings of Newton – it is more important, I believe, to examine the form of the new consensus. For, despite internal dispute, the call for reformulation united Leibnizians and anti-Leibnizians, Stahlists and anti-Stahlists, Newtonians and anti-Newtonians[9]. Within this

6 P. S. PALLAS, Beobachtungen über die Berge, und die Veränderungen der Erdkugel, besonders in Beziehung auf das russische Reich, in: Sammlungen zur Physik und Naturgeschichte von Liebhabern dieser Wissenschaften, 1. Bd., 2 Stück, Leipzig 1778, p. 134–135.

7 My use of the words »order of things« and »discourse« may suggest the influence of Foucault's formulations on my work. I am more than ready to admit such an influence, though the specifics of my exposition here differ considerably from those of Foucault. The main reason that I choose to use these terms is that eighteenth century thinkers themselves chose them to describe nature. This is made evident by Adam Ferguson who was an avid reader of the new natural sciences. He described the material world as a system of »signs and expressions«, a »magnificent but regular discourse«. Adam FERGUSON, Principles of Moral and Political Science, 2 vols., Edinburgh 1972, I, 275. And in all of this works he continually referred to the »order of things«. See footnote 52.

8 Only recently has this widespread late Enlightenment disenchantment with mechanical natural philosophy begun to be investigated. For an excellent analysis of the changes in the life sciences in France during the eighteenth century see Jacques ROGER, Les Sciences de la vie dans la pensée française du XVIII[e] siècle, Paris 1971. Colin KIERNAN has argued in a similar vein in The Enlightenment and Science in Eighteenth-Century France, Oxfordshire 1973 (Studies on Voltaire and the Eighteenth Century, ed. Theodore Besterman). Sergio MORAVIA has written an outstanding article discussing the change in the concepts of human nature, From Homme Machine to Homme Sensible: Changing Eighteenth-Century Models of Man's Image, in: Journal of the History of Ideas 39 (1978). Robert SCHOFIELD has written a very important book tracing these important shifts in physics in England, Mechanism and Materialism: British Natural Philosophy in the Age of Reason, Princeton 1970. I have dealt with similar problems for Germany in the following articles: Die Geschichtswissenschaft um die Mitte des 18. Jahrhunderts, in: Wissenschaften im Zeitalter der Aufklärung, ed. R. VIERHAUS, Göttingen 1985, Narration and Structure in Late Eighteenth-Century Thought, in: History and Theory, XXV (1986), Science and the Science of History in the Spätaufklärung, in: Aufklärung und Geschichte: Studien zur deutschen Geschichtswissenschaft im 18. Jahrhundert, eds. H. BÖDEKER, J. KNUDSEN, G. IGGERS, and P. REILL, Göttingen 1986.

9 Here, for example, the case of Newton is extremely interesting. Usually, Newton is considered the major source for the spectacular rise of mechanical natural philosophy during the first half of the

emerging consensus, the person most often cited as the leader in the revolt against mechanism was George Buffon. For many late Enlightenment thinkers, Buffon's magisterial »Histoire Naturelle« had proposed a compelling new method and set of principles for the study of nature. It also had established a range of problems that would occupy thinkers in diverse fields of inquiry for years to come. In this sense, though other writers such as Maupertuis and to a certain extent La Mettrie preceded him [10], Buffon's »Histoire Naturelle« can be considered the symbolic starting point for the late Enlightenment revision of science.

Buffon's approach was founded upon a new concept of scientific method, concisely presented in the introductory chapter of the first volume. Entitled »Le Discours de la manière l'étudier et de traiter l'Histoire naturelle«, it clearly was designed as a critique of Descartes' »Discours de la Méthode«. In it Buffon attacked the two prominent traditions of contemporary scientific inquiry that were then vying for supremacy: simple empiricism and mathematical mechanism. He disposed of the first by categorizing it as a mindless endeavor, the product of antiquarian delight in the undigested fact. It said too much and had nothing to say [11]. The second and major task, that of providing both a critique and an alternative to mathematical-mechanical reasoning was far more difficult. For here, Buffon seemed to undermine the very foundations upon which the advances of late 17th century science had been built.

Mechanical natural philosophy, in its various guises, had been guided by the imperative to transform contingent knowledge into certain truth, to reduce the manifold appearances of nature to simple, quantifiable principles. Mathematics was seen as the tool that would enable one to achieve this feat: it became the eye of natural philosophy and its language of exposition. Buffon launched a direct attack upon mechanical mathematical reasoning by denying the efficacy of mathematics to reveal the »secrets of nature«. His critique of mathematical procedures was based on a distinction he drew between abstract truths and physical truths. The first were products of human invention, they were imaginary. The second were real, they existed in nature. Mathematical proofs belonged to the first category; in fact, they were its prototype. Buffon argued that mathematics was based upon arbitrarily accepted logical principles. These, then, were used to generate equally arbitrary principles. All were joined by a method of definition whereby consistency was maintained by rigorously excluding anything that did not agree with the first abstract principle. In effect, Buffon argued, mathematical reasoning was a tautology, it was incapable of saying anything other than that with which it

eighteenth century. As a rule, one has interpreted Newton as a thinker with a coherent philosophy of nature that could be abstracted from his Principia. However, as Robert SCHOFIELD has demonstrated in Mechanism and Materialism (see n. 8) Newton was read and interpreted in many ways. In Newton's work, there were enough contradictions to allow a totally different reading of him at the mid-century mark than had been done at the beginning of the century.

10 La Mettrie is often considered as the archetype of the mechanical philosophy of the Enlightenment raised to its highest degree. But though he employed the metaphor of man the machine, he also transformed the idea of an »organic machine« so radically that it had little to do with traditional mechanist explanations. As Aram Vartanian notes, La Mettrie's »primary task was to vitalize the Cartesian ›dead mechanism‹ approach to biology. In order to lift the homme machine beyond the reach of animistic criticism, La Mettrie had first to show that purposive motion could only be a property of organized matter as such, or, put differently, that the man-machine was automatic in a manner that no man-made machine, requiring direction from without, could truly duplicate«. Aram VARTANIAN, La Mettrie's L'Homme Machine: A Study in the Origins of an Idea, Princeton 1960, p. 19. As Vartanian demonstrates in his excellent introductory monograph, it is necessary to analyze the content of a work before assigning it to a specific genre or trend. It is clear that La Mettrie had much more in common with Buffon, Maupertuis, Diderot and the eighteenth-century vitalists discussed in this paper than is commonly supposed.

11 George L. BUFFON, Allgemeine Historie der Natur, trans. Abraham Gotthelf Kästner, Leipzig 1750, p. 18.

began. A mathematical proof was sterile[12]. Physical truths, in contradistinction, were based on things that have actually occurred. They were not mere products of human reason. Hence we could not control them at will. To understand them, we are forced to compare and observe similar sets of real occurrences. Science, according to Buffon, was a description and understanding of real things that have occurred. Therefore, mathematics was not a suitable language for expressing scientific truth. Rather, science should be essentially historical in form. It must be descriptive. Here again, Buffon took direct aim at mechanical natural philosophy, for according to most late seventeenth-century thinkers, history was the lowest form of knowledge: all it could do was offer contingent knowledge. It was incapable of presenting certain truth[13].

Buffon's critique of mathematics formed one part of a two-pronged assault on mechanical natural philosophy. The second was his attempt to redefine the properties of matter. Most mechanical natural philosophers – here the Leibnizians seem to be an exception – had, in their efforts to achieve clarity, divested matter of all non-quantifiable qualities. These non-quantifiable properties were derisively referred to as »occult qualities«, a linguistic ploy that associated them with »magic« and »superstition«, not with science. Mechanists defined matter as particulate, extended, impenetrable, and endowed with inertia. Mass, shape, imparted motion, and equal action and reaction formed the principle categories to which mathematical analysis had been applied. Buffon did not deny the validity of these categories, but he argued that they were insufficient to account for all physical phenomena, especially for the phenomena of life. Employing the analogy of gravity, which he termed an »occult force«, Buffon posited the existence of other occult forces, invisible to the human eye, yet continuously active in shaping and maintaining nature[14]. In fact, he went so far as to claim that these invisible forces accounted for most material phenomena[15]. Buffon employed a topos that was not new, but that was to become dominant during the last half of the eighteenth and the first third of the nineteenth century. Invisible, active, internal force became a central characteristic for all living and organized matter.

A second feature of Buffon's revised definition of matter dealt with the manner in which bodies were organized. Early eighteenth-century mechanical natural philosophy had assumed that all bodies, whether inanimate or not, were simple aggregates built from identical units of inert matter. In theory, these bodies could be broken apart, the identical parts isolated, and

12 Ibid., I, p. 36. *Mathematischen Wahrheiten* (sind) *bloß Erklärungs- oder Definitionswahrheiten, oder wenn man es verlanget, verschiedene Ausdrückungen von einerley Sache, und daß sie nur in Beziehung auf diejenigen Erklärungen, die wir selbst gemacht haben, Wahrheiten sind. Aus dieser Ursache haben sie den besondern Vorzug, daß sie allezeit richtig und bindig, zugleich aber abstrakt, geistig und willkürlich sind.* The degree to which the position became accepted by many natural philosophers is attested to be the Halle mathematician and physicist W. J. G. Karstens: *Mathematische Lehrsätze mit ihrem Beweisen gehören also nicht zur Naturlehre; es ist Einmischung fremder Sätze, wenn Schriftsteller sie vortragen, welche Physik, nicht Mathematik lehren wollten ... Hiermit wird nicht behauptet, daß man gar keinen mathematischen Lehrsatze in der Physik Anwendung machen müsse: Daß ist ganz etwas anders, als wenn man einen solchen Lehrsatz oder mehrere dergleichen Lehrsätze mit ihrem Beweisen in den Vortrag der Physik verwebt, nicht anders, als wenn sie zum System der Physik gehörten,* Physische-chemische Abhandlung, durch neuere Schriften von hermetischen Arbeiten und andere neue Untersuchungen veranlasset, 2 vols., Halle 1786–1787, II, pp. 3–4.

13 This is the definition Christian Wolff gives of history in Gesammelte Werke 1 Abt., Deutsche Schriften I, p. 115.

14 Buffon, Historie der Natur (see n. 11) II, p. 28. *Aus dem was wir ... gesagt haben, erhellet, daß sich in der Natur Kräfte ... befinden, die zum Innern der Materie gehören, und mit dem äußern Eigenschaften der Körper keinen Zusammenhang haben, sondern die auf die innersten Theile wirken, und solche in allen Puncten durchdringen. Diese Kräfte können wie wir beweisen haben, niemals unter unsere Sinnen fallen, weil ihre Wirkung auf das Innere der Körper geht.*

15 Ibid., p. 29.

then the whole reconstructed synthetically. Cause and effect was the equal physical action and interaction of these individual bodies, typically conceived of in terms of imparted motion. A scientific system, then, was a logical ordering of independent variables whose causal connections were directly proportional, simple, and quantitatively determinable. In essence, mechanical natural philosophy was reductionist. Buffon argued that living bodies could not be described in such a manner. Rather than being aggregates, they were conjunctions in which all elements were symbiotically related. It would be impossible to isolate or subtract a single element from the whole without changing substantially the relations between the remaining parts. Reality was conceived as a set of relations or *rapports* existing between mutually interdependent parts. Taken together, the *rapports* and the parts constituted the whole or *Gestalt,* which because of the complex relations between the parts formed a unique individuality, never wholly identical with any other[16]. Further, each individual existed within a specific milieu or habitus, which helped condition that body and thereby placed it within another set of complex relations. In all, then, nature consisted of unity in multiplicity.

Buffon sought to formulate a concept of scientific system capable of elucidating these complex relations. He called it a »natural system«, which, unlike artificial, arbitrary, or reductionist ones, enabled the natural philosopher to describe a body as it actually was. However, Buffon's vision was an ideal, never totally realizable because of the complexity of a body's internal and external relationships[17]. The imperative to describe a body in its totality, however, posed the question of how such a system could be constructed. What procedures could one employ to organize such diverse materials and arrive at statements that could be considered laws? This project, announced by Buffon, animated the activities of many late Enlightenment scientists. It was obvious that given the complexity and individuality of organized bodies, relations of identity could not be established. In the real world, all one could discover were similarities of varying degrees. Since outward form was no longer critical, and since the body was no longer considered a passive entity receiving imparted motion, this analysis required a study of active force systems that worked in conjunction and that constituted the body. It was necessary to compare the functional operation of these systems amongst as many classes of living organisms as possible. Hence, comparative, functional analysis became the basic operational mode of the new science. In these operations function replaced form. Outward characteristics were either considered secondary phenomena or manifestations of the activity of internal forces. Comparison of function, the emphasis upon similarity, and the fascination for active, invisible forces led Buffon to emphasize the centrality of analogical thinking. For most late Enlightenment natural philosophers, analogical reasoning was raised to the primary principle of research and explanation.

Buffon joined all of these elements in a revised definition of systematic scientific analysis which was further elaborated throughout the rest of the century. The creation of a natural system required the following operations; isolate and describe the various sub-systems according to function and effect; measure the intensity of these systems under various conditions; attempt to see how they modified one another; and then try to envision them working together as a whole, where all subsystems interacted synergistically[18]. This last operation – the apprehension of the whole – called for a new type of understanding capable of mediating between the general and the particular. Detailed empirical research was to be guided

16 Ibid., p. 13.

17 Ibid., I, p. 20. Such a description included *die Gestalt, die Größe, die Schwere, die Farben, die Lagen in der Ruhe und in der Bewegung, die Stellen der Theilen mit ihren Verhältnisse, ihrer Gestalt, ihrer Wirksamkeit...*

18 The word synergy was employed by Stahl in his animist theories of life and then adopted by the leading medical thinkers of Montpellier and Paris. Barthez defined it as follows: *Je designe par ce mot de synergie, un concours d'actions des forces de divers organes, qui cooperent avec un organ detérmine.* Jean BARTHEZ, Nouveaux Elements de la science de l'homme, Montpellier 1777, p. 59.

by creative scientific imagination. The natural philosopher was to be both an artist and a gatherer of facts. »Love of the study of nature implies, in the human mind, two attributes which appear to be opposed, the broad outlook of an ardent spirit that grasps everything in one glance and the minute attention of a hard-working instinct that concentrates on only one point«[19]. The process of apprehending the whole was usually termed *Anschauung*, intuition, or divination, terms which became increasingly employed to characterize the goals of scientific understanding[20]. Macquer described this process in his chemical dictionary. The scientist was someone »with the genius to perceive *(le génie d'appercevoir)* in one overview the immense multitude of chemical phenomena«. And Macquer defined science as the »study and knowledge of the relations *(rapports)* that a certain number of facts can have with each other«[21].

Buffon also carried his attack upon mechanical natural philosophy into the area of animal reproduction. The physiological counterpart to mechanism was embodied in the theory of preformation. It asserted that God had, in the beginning, created the »germs« – microscopically small, but fully formed individuals – for all humans, animals, and plants that have lived or shall live. These germs were encased in the original parent, either in the womb (Bonnet, Haller, Spallanzani) or in the sperm, depending upon which theory of preformation one held. When the time came for each individual to emerge, it just »developed«, that is it expanded quantitatively, but did not otherwise change. The opposing physiological doctrine was epigenesis. It argued that the embryo began as a point of living material and then evolved through the successive formation of distinct structures until the fully formed individual emerged. The battle between both views was hard and ranged over the problems of monstrous births (why would God create imperfect germs), hybrids (where are the germs for them), artificial insemination (a sign of the existence of germs in the womb), and ontogenesis (Trembley's famous polyps). The most decisive argument the preformationists used was that epigenesis could not account for continuity of form. If the theory of epigenesis were true, they asked, why aren't we continually confronted with all types of strange creatures, half man, half animal and so on. Yet, when we look at nature we see that humans continue to look like humans, dogs like dogs. Buffon an epigenesist sought to answer this critique and argued for the existence of a *moule intérieur*, or internal mold, which determined an animal's external shape and internal form. Each genus had its own *moule intérieur* which differentiated it from others, thus precluding the infinite combinations that preformationists said must take place according to epigenesist theory. In effect, Buffon attempted to resolve the tension between structure and change by assuming the existence of some kind of prototype or ordering principle.

Buffon's work provides us, either explicitly or implicitly, with a matrix of assumptions that came to characterize late Enlightenment scientific thought and practice. Within this matrix a new vision of nature was formed, new procedures proposed, and important discoveries made. For many, this vision of science was appealing both because of its apparent successes and its ability to speak directly to analogous issues concerning human action. This model spread quickly along lines of least resistance, touching first those disciplines not connected to the life sciences and least dependent upon atomism and then moving into the harder sciences until physics itself was reshaped.

19 Buffon, Historie der Natur I (see n. 11) p. 4. *Die Erlernung der Naturwissenschaft setztet zwo solche Tugenden, die einander entgegen zu stehen scheinen, voraus, nämlich die große Einsicht eines feurigen Geistes, der alles in einen Augenblick zusammenfaßt, und die kleine Aufmerksamkeit einer natürlichen Arbeitsamkeit, die sich nur auf ein einzelnes Stück leget.*

20 Ibid., I, p. 15.

21 Quoted and translated by Wilda C. Anderson, Between the Library and the Laboratory: The Language of Chemistry in Eighteenth-Century France, Baltimore 1984, pp. 22 and 158.

III

Any model of science that is to be convincing must be capable of being extended and refined. It must demonstrate its ability to produce new »truths«, to integrate older ones into its system, and even to reconsider ones that have played a part in its original formulation. It must presume to present an »order of things« that encompasses perceived reality. This certainly seemed to be the case for the anti-mechanist, vitalist vision of the late Enlightenment. Very quickly, existing sciences were reformulated upon this model and new ones were created. In the process, new distinctions and sub-disciplines were defined, each directing these general assumptions to specific questions. Here two examples should suffice. In medicine the sub-disciplines of physiology, pathology, comparative anatomy, osteology, and embryology acquired their distinctive forms. In mineralogy five sub-disciplines were created, each requiring, as Abraham Gottlob Werner declared, its own specific systematic ordering, for »the order one science requires is generally opposed to that required by another science«[22]. This process of reformulation, refinement, and specification was carried out throughout Europe and was, in its broadest context an international movement, though certain centers played a critical role. For western and central Europe, the most important centers of activity were Edinburgh, Glasgow, Montpellier, Paris, Strasbourg, Geneva, Göttingen, Freiburg, and, towards the end of the century, Mainz, Stuttgart and Berlin. The movement was aided by the creation of a wide and extensive communication network between scholars, the appearance of general and specialized journals in which major scientific publications were quickly reviewed, the translation of an increasing number of scientific works, the institutionalization of these subjects in schools and universities, and the founding of numerous societies and reading clubs where amateur scientists would present their findings and where major theories were debated. For the educated reading public of the last half of the century, the largest single category of books published and those discussed in journals was devoted to the natural sciences.

Though this was an international movement, it was accompanied by the emergence of specific national traditions, each with its own style and interests, each defining itself within its own context of existential issues and against similar but not identical formulations made by scholars from other traditions. What I would like to do is compare movements occurring in Scotland and Germany to show how similar assumptions could produce different results. Obviously, since space is limited, I can only concentrate on a few examples that I believe are representative.

Certainly, when one looks at Scotland in the second half of the century, the blaze of productivity that occurred in all areas of intellectual pursuit is staggering. However, as far as I can judge, most scholarly interest has been focused on the subjects of social thought and philosophy, less on natural science, and even less on the possible connections between Scottish natural science and the science of society. When the last has been attempted, it has often been assumed that as »Enlightenment thinkers« people like Adam Smith or Ferguson naturally believed in mechanistic atomism[23]. This can only be maintained by ignoring the fact that anti-mechanism was a central feature of late eighteenth-century Scottish science, informing works from physiology to chemistry and physics. Further, it is often forgotten that the leading anti-mechanists were an integral part of the small Scottish intellectual elite: they were the friends,

22 Abraham Gottlob WERNER, Von den verschiedenerley Mineraliensammlungen, aus denen ein vollständiges Mineralienkabinett bestehen soll, in: Sammlungen zur Physik und Naturgeschichte von Liebhabern dieser Wissenschaften, 1 Bd., 4 Stück, Leipzig 1778, p. 393.

23 Gideon FREUDENTHAL, Atom und Individuum im Zeitalter Newtons: Zur Genese der mechanistischen Natur und Sozialphilosophie, Frankfurt 1982. Freudenthal considers both Smith and Rousseau as atomists and mechanists and he concludes that mechanism was dominant for the whole Enlightenment.

colleagues, fellow club members, and sometimes relatives of their now more famous contemporary philosophers and social scientists[24]. Hence, it might be important to quickly rehearse some of the central features of late 18th century Scottish science.

One feature was the close connection between the disciplines of medicine, chemistry and physics, a tie that Baader saw as the result of anti-mechanist thinking[25]. Here the names of Cullen, Black, Irvine, Crawford, Watt, and Elliot are central. All of them rejected the idea of the uniform composition of matter and the assumption that extension, shape, and imparted motion were the basic explanatory criteria of science. They directed much of their attention to the nature, generation, and retention of heat, important topics because of the close association of heat und life. The experiments of Cullen, Black, and Irvine that led to the formulation of the theories of latent and specific heat seriously questioned mechanistic principles. It became apparent to them that since each element or compound had its own ability to retain a certain amount of heat – an ability not explicable by its size, shape, or weight – then something else must be introduced to account for these properties. Their answer was that each element or compound was a unique entity animated by an invisible force that determined how much heat could be retained. Heat generation reinforced this view. The Scottish chemists were convinced that combustion was a chemical process in which heat was produced by the combination and recombination of different elements. Why this should happen was explained by a revised theory of chemical affinity. Unlike earlier theories of chemical affinity where like attracted like (the example of two drops of water combining), now it was argued that unlike attracted unlike with varying degrees of intensity that could be measured and described. Chemical processes, including combustion, were framed in terms of an activity taking place between two different, if not opposing elements or substances. From such observations, polarity emerged as an important part of scientific explanation that received further support from the phenomena of magnetism and electricity. But what then was heat? Since it was no longer sufficient to think of it in terms of friction caused by moving particles rubbing against each other, the Scottish chemist-physicists saw it as a special substance, a subtle fluid passing from one body to another during the process of chemical combination and recombination[26]. They used the language of materiality to describe it: heat was either released or retained. But, if heat were a

24 This was true for Joseph Black who was Adam Ferguson's cousin. Ferguson wrote the first biography of Black and was an avid reader of the life sciences.

25 The German mathematician W. J.G Karstens provides an another example of those who wished to join chemistry and physics based upon an altered view of matter. In so doing, he argued that discussions about the ultimate nature of matter were irrelevant. *Unter den allgemeinen Eigenschaften der Körper hat man bisher allemahl auch ihre Theilbarkeit angeführt, und diese hat eine Menge sehr gelehrt scheinender im Grunde aber ganz unfruchtbarer Untersuchungen veranlasset ... ob die Materie der Körper ins unendliche theilbar sey, oder ob man durch fortgesetzte Theilung auf letzte Theile komme, die keine fernere Theilung zugelassen? ob man diese letzten Theile für ganz einfach halten müsse, die keine Figur und Größe mehr haben? oder ob man ganz kleine nicht weiter theilbarer Körperchen dafür annehmen müsse? ob sie Monaden, Atomen, physische Puncte, oder noch anders heißen sollen? Mit dergleichen Untersuchungen unterhielte man sich, als man noch nicht viel besseres wußte: jetzt kann der Physiker seine Leser oder Zuhörer weit lehrreicher unterhalten. Die Möglichkeit oder Unmöglichkeit einer mechanischen Theilung ins Unendliche oder bis auf ganz kleine noch körperliche Atomen ist ihm sehr gleichgültig, er kennt andere Arten von Zertheilungen, oder wie man es besser ausdrückt, ander Arten von Zerlegungen körperliche Stoffe in ihre ungleichartigen Grundmaterien, die ins Reich der Wirklichkeit gehören.* KARSTENS (see n. 12), vol. 2, p. 69.

26 For example, Crawford saw Heat and Phlogiston as two opposing substances. *Wärme und Phlogiston scheinen also zwei einander entgegengesetzte Stoffe in der Natur zu seyn. Doch die Wirkung der Wärme auf die Körper wird ihre Anziehungskraft, die sie gegen das Phlogiston äußern, vermindert, und durch die Wirkung des Phlogistons wird ein Theil der absoluten Wärme, welche als ein elementarischer Stoff in allen Körpern enthalten ist, aus denselben entbunden.* In: John ELLIOT, Physiologische Beobachtungen über die Sinne besonders über das Gesicht und Gehör wie auch über

fluid, what then was light, electricity, magnetism? Increasingly each of these things were considered animated subtle fluids – the opposite of a mechanist's vision of a world composed of atoms joined in different configurations and separated by vast spaces. Fluidity replaced hardness and impenetrability as the basic metaphor for matter.

These researches into heat generation and retention were then applied to animal life through the use of analogical reasoning. A basic analogy was posited between »animal heat« (body temperature) and combustion which Crawford and Elliot sought to investigate. They associated it with respiration, noting that animals with the largest respiratory systems proportional to body size had the highest body temperatures[27]. Crawford compared the air an animal expired with that produced by a burning candle and found that they were the same (fixed air). And he designed experiments to show that the act of breathing involved the combination and liberation of a basic stuff for life, a *pabulum vitae*. These experiments pointed, however, to another phenomena of life not explicable by the analogy of combustion, namely the ability of many animals to regulate body temperature, to stay cooler than the surrounding environment. Crawford thought the body capable of also producing cold – another subtle fluid, the polar opposite of heat. Others weren't so sure, but they all agreed that the living body had its own internal »economy«, its own laws of motion that defied the normal laws of inanimate matter. This image of the self-sufficiency of the animal economy was central to Enlightenment anti-mechanist vitalism and is the point I would like to concentrate upon in the comparison between the Scottish and German explanatory models.

In their investigations into the animal economy, Scottish physiologists emphasized the priority of the central nervous system in directing the activities of an organized body. This was elaborated by one of the first and most interesting Scottish anti-mechanists, Robert Whytt (1714–1766). His major book, »An Essay on the Vital and other Involuntary Motions of Animals« (1751, 1763^2), dealt with those areas of the animal economy that mechanists and animists had the most difficulty explaining, involuntary and semi-voluntary animal motion. For mechanists these human functions – for example, the beating of the heart, the digestive system, the circulation of blood, and the simulation of the genitalia – were »automatic« activities, not explicable by mind and therefore necessarily produced *by virtue* of their *mechanical construction*[28]. Animists such as Stahl reversed this explanation and ascribed all animal motion to the action of a *rational agent*, namely the soul. Whytt, like most late eighteenth-century vitalists, sought a middle ground between them, though he tended more to Stahl than to the mechanism of Descartes and Boerhaave.

In his explication, Whytt proposed three central arguments. The first was that the animal system could not be comprehended under the idea of a machine. He employed the concepts of *organic conjunction* and *active forces* to justify this position. *The human body, in which there is no mover that can properly be called First, or whose motion depends on something else, is a system far above the power of mechanics*[29]. This he demonstrated through a series of examples, built upon comparison and analogy, by showing that the concept of mechanical cause and effect is insufficient to explain muscle contraction. When touched, muscles contract with a force much greater than the original cause. They continue to contract and relax, following a pulsating pattern well after the original cause has disappeared. Simply said, the reaction is not directly proportional to the original force. Thus, there must be a different type of force which causes these motions. Whytt called this force »the energy of the mind« or the »sentient principle«.

das Brennen und die thierische Wärme nebst Adair CRAWFORDS Versuchen und Beobachtungen über die thierische Wärme, Leipzig 1785, p. 230.

27 CRAWFORD, (see n. 26), pp. 192–193.

28 Robert WHYTT, An Essay on the Vital and other Involuntary Motions of Animals, Edinburgh 1763^2, p. 2.

29 Ibid., p. 299.

His second argument was directed towards drawing a differentiation between this active principle and Stahl's theory that vital motion was »presided over, regulated, and continued« by the conscious, rational mind[30]. Whytt did this by denying that reason and consciousness were the defining characteristics of mind. Both were functions of the mind but not the primary ones. *Upon the whole, there seems to be in man one sentient and intelligent Principle, which is equally the source of life, sense and motion, as of reason*[31]. The most basic property of vital matter was sensation, whereby mind receives a stimulus, processes it, and then reacts. This takes place, as a rule, without the active intervention of reason. Since *there are actions, towards the performing of which* are *in no ways determined by reason*, the *mind is not a free but a necessary agent*[32]. This may sound Lockean, but Whytt refused to accept the mechanical implications often ascribed to Locke. Mind was not a passive receiver of sensations. It was endowed with its own *energy* that produces effects greater than the received stimulus: hence, the already mentioned disparity between cause and effect. Whytt replaced the concept of cause and effect with that of stimulus and what we would call *reflex action*. The animal economy can thus be considered a *perpetuum mobile* because of this ability of *a cause producing an effect greater than itself, but also an effect increasing by degrees, ... of its own accord*[33].

Whytt's third argument was that all animal motion was directed by the *energy* of the central nervous system. Here he had to overcome two hurdles. First, it was evident that no single common place could be found where all animal nerve endings met. That is, there simply was no physical contact between them, which for many thinkers of the time made it difficult to conceive of directed motion. Second, there was no clear proof that the nerves controlled muscle contraction. He answered the first by pointing to the existence of *sympathetic reactions* between parts of the body that had no direct contact with each other and whose nerves did not *terminate precisely in the same part of the brain*[34]. He claimed that only the existence of a principle of energy binding the brain, spinal chord, and the nerves could account for this sympathy. *The sympathy, therefore, or consent observed between the nerves of various parts of the body ... ought to be ascribed to the energy of that sentient Being, which in a peculiar manner displays its powers in the brain, and by means of nerves, moves, actuates, and enlivens the whole machine*[35]. Whytt also used the concept of sympathy to overcome the second hurdle. *Muscles*, he claimed, *are excited into action by a stimulus affecting a remote part with which they have no immediate connection, or so much as even a communication by means of nerves, unless it be that general one subsisting between all parts, as their nerves are derived from the same brain*[36]. But in this case Whytt's crucial argument was drawn from a general proposition that had very little to do with muscles. Arguing that nature did nothing in vain and that it always chose the simplest solution, it would be silly to ascribe to muscles any particular power that was not controlled by a more general force. With a grand rhetorical flourish which Whytt thought devastating, he rested his argument with the following assertion. *But if it be imagined that he ›the all-wise Author of nature‹ has given to animal fibres a power of sensation, and of generation motion, without superadding or uniting to them an active Principle, as the Subject and Cause of these, we presume to say,*

30 Ibid., p. 316.
31 Ibid., p. 321.
32 Ibid., p. 338.
33 Ibid., pp. 297–299. A similar argument was posed by La Mettrie. Like Whytt, he was fascinated with the problem of muscle contraction and irritability and like him described the animal machine in terms of perpetual motion. *Le corps humain est une Machine qui monte elle-même ses ressorts: vivante image du mouvement perpétuel* quoted by VARTANIAN (see n. 10) p. 20.
34 Whytt (see n. 28) p. 299.
35 Ibid., p. 204.
36 Ibid., p. 264.

that a supposition of this kind ought by no means to be admitted; since, to affirm that matter can, of itself, by any modification of its parts, be rendered capable of sensation, or of generating motion, is not less absurd than to ascribe to it a power of thinking[37].

A year after the publication of the first edition of Whytt's book, Germany's most eminent physiologist, Albrecht von Haller, read a paper before the Royal Society of Sciences in Göttingen entitled »Von den empfindlichen und reizbaren Teilen des menschlichen Körpers« that proclaimed precisely what Whytt thought absurd. Published in 1753 it became one of the most influential scientific tracts of the last half of the century. Unlike Whytt, it would be hard to consider Haller an anti-mechanist. He was Boerhaave's prize student and had invested much of his emotional and intellectual energy in propagating and refining mechanistic physiology. As a devout Calvinist, he found the mechanistic belief in an all powerful creator who continually directed a world machine that otherwise was destined to run down, theologically persuasive. Yet, whatever Haller's personal opinions, this work led to the types of materialist assumptions Whytt had castigated. It also established a precedent for the form of physiological thinking evolved by late eighteenth-century German vitalists. The crucial element in the work was Haller's differentiation between two different and opposed types of powers, residing in the organized body that he called sensibility and irritability. He defined both as follows: *I call that part of the human body irritable which becomes shorter upon being touched; very irritable if it contracts upon a slight touch … I call that a sensible part of the human body, which upon being touched transmits the impressions of it to the soul*[38]. These two powers were contained in different types of matter and were opposed: *that the most irritable parts are not at all sensible, and vice versa, the most sensible are not irritable*[39]. Thus, nerves were only capable of sensibility, muscles of irritability. Through a host of gory experiments upon living animals, Haller established, what, he believed, were basic categories of matter with different types of internal powers. *The internal membranes of the stomach, intestines, bladder, uterus, vagina, and womb* were sensible, while *the viscera, … viz. the lungs, liver, spleen, and kidneys had very little sensation*[40]. The organ with the greatest degree of irritability was the heart. In addition to these types of matter animated by either sensibility or irritability, Haller also discerned other types of matter which belonged to neither category. This included the bones and cellular material, which seemed to have the power of elasticity. In effect, Haller proposed a view in which different force systems worked within the animal body. Though virtually independent of one another, they function in a kind of complicated interrelated system. Therefore, while Whytt sought to argue for spiritual centralization, Haller saw a decentralization of active powers.

This pattern of multiplying internal forces became a characteristic feature of late Enlightenment German physiology. Thus, in the 1760's Hermann Samuel Reimarus introduced the concept of animal drives *(Triebe)* and Caspar Friedrich Wolff a convinced epigenesist posited the existence of a *vis essentialis* to explain its action. But probably the most important and influential representative of German vitalist thought was Johann Friedrich Blumenbach (1752–1840). Blumenbach held the professorship of physiology and anatomy at Göttingen from 1775 to 1840. He was the teacher of two generations of physicians, physiologists, comparative anatomists and physical anthropologists. Amongst his students were some of the most important life scientists of the time, including Samuel T. Sömmerring, Johann Reil, Joachim Brandis, Gottfried Treviranus, Carl Friedrich Kielmeyer, and Johannes Müller. Blumenbach's correspondence was vast and his writings widely read and translated. The

37 Ibid., p. 268.

38 Albrecht von Haller, A Dissertation on the Sensible and Irritable Pats of Animals, London 1755, reprint by Owsei Temkin, Baltimore 1936, pp. 658–659.

39 Ibid., p. 675.

40 Ibid., p. 672–673.

influence his physiological theories had on contemporary thought was acknowledged by no less than Goethe, Kant, and Wilhelm von Humboldt.

In Blumenbach's physiology, organic life was governed by a combination of general and specific vital forces working together in harmonic conjunction. He discerned a number of *common or general vital energies that exist more or less, in almost all, or at least in a great many parts of the body*[41]. The foremost of these was the *Bildungstrieb*, which Blumenbach defined as *a power perpetually active, perpetually efficacious, the immediate destination of which is, first to mould the bodies in which it resides into their native and specific forms by the mysterious process of generation, to preserve them afterwards from destruction by the ceaseless function of nutrition, and, in case of accidental mutilation, to restore the parts again ... by the process of reproduction*[42]. Not only was the *Bildungstrieb* an active power, it had a goal or telos, that of directing the »admirable successive transformations« and »metamorphoses« that an organized body undergoes[43]. Blumenbach posited the *Bildungstrieb* as the force propelling epigenesis, development, daily maintenance and the body's reaction to internal and external disturbance. It accounted for structure and growth. In this sense the *Bildungstrieb* combined the *two principles ... that one had assumed could not be joined, the teleological with the mechanical*[44]. In addition to these general vital powers, Blumenbach posited another vital energy, *namely, the vita propria, or specific life; under which denomination I mean to arrange such powers as belong to certain parts of the body, destined for the performance of peculiar functions*[44]. According to this view, *virtually every fibral in the living body possessed a vital energy inherent in itself*[45]. Here the contrast to Whytt is radical. An organized body consisted of a complex conjunction of energies and forces of varying intensities and functions. All of these energies act upon each other and are influenced by the *total habitus* in which they exist. The aim of scientific explanation was to account for both the complex force field of the organized body and the environmental effects that could redirect, enhance or diminish, or even change these forces. The only way such an explanation could be achieved was to compare similar organic entities, seek basic correspondences, and construct a system of classification capable of incorporating the greatest number of these features. However, given the multiplicity of connections and the impossibility of ever piercing the *Cimmerian darkness* in which the causes of active powers are veiled, such a system was, at best, a heuristic, a guide to discovery, but not true in itself[46]. For similar reasons, nature's telos could only be intuited, never fully revealed as transparent. In effect, teleology, though central to his physiology, was an ideal in the Kantian sense, regulative but not determinant. Perfectibility was possible and desired, but not an ontologically determined given. Natural history was always a story told in the conditional tense. Here Blumenbach seems much closer to Buffon than to Whytt. His model allows for change, yet integrates variability in a much more consistent manner. At the same time, because of the model's complexity, it makes it much more difficult to envision how this change could or should be directed. Still, though differing greatly, both Whytt and

41 Johann Friedrich BLUMENBACH, Elements of Physiology, trans. Charles Caldwell, Philadelphia 1795 I, 33.

42 Ibid., 22. Blumenbach called it an »occult quality«. *Hoffentlich ist für die mehresten Leser die Erinnerung sehr überflüssig, daß das Wort Bildungstrieb, so gut wie die Worte Attraction, Schwere etc. zu nichts mehr und nichts weniger dienen soll, als eine Kraft zu bezeichnen, deren constante Wirkung aus der Erfahrung anerkannt worden, deren Ursache aber so gut wie die Ursache der genannten, noch so allgemeinen anerkannten Naturkräfte, für uns qualitas occulta ist.* BLUMENBACH, Ueber den Bildungstrieb, Göttingen 1791[2], pp. 33–34.

43 Johann Friedrich BLUMENBACH, Handbuch der vergleichende Anatomie, Göttingen 1805, p. 512.

44 Ibid., 65–66, fn.

45 Ibid. 22.

46 Ibid. 177.

Blumenbach were convinced that they had described the order of things in a manner far superior than had been proposed by the »mechanical philosophers«. For them this revolution in scientific thought was both real and progressive.

IV

Science is not generated in a vacuum and, despite the claims of some historians of science, does not, I believe, develop merely according to a rational, internal logic. Rather, it is a social product created by thinkers at a specific time which necessarily answers and responds to existential needs. It gives meaning to nature and life and, in so doing, incorporates vitally felt issues into its very logic of explanation. Thus, any large-scale shift in scientific conceptualization should indicate a similar shift in society, or rather within the society to which scientific thinkers belong, for, as Trevor J. Pinch maintains, »cognitive conflicts in science are inseparably social conflicts«[47]. If this be true, it should be possible to identify a considerable shift in sensibilities that accompanied and made the rise of late Enlightenment vitalism possible. But how can this be done without doing interpretive violence to either the science or the society in which it was embedded? Too often in externalist histories of science, science has been seen as mere ideology, reflecting something more basic called society. And society has often been categorized in absolutistic ways employing terms such as classical, feudal or bourgeois that assume more than they prove. The only way I can see of escaping the reductionist dangers of such an endeavor is to begin with a close reading of the science of a period, attempting to discern structural similarities and keeping an ear or eye open for phrases, concepts, or explanatory figures that could suggest possible social or political meaning. When this is done, one should be able to extend and refine the analysis to encompass wider spheres of experience. I would like to cite just one example where, I believe, late Enlightened vitalistic science incorporated and helped define what might be called a latent political message. In so doing it lent that political sensibility authority by »naturalizing« it, by integrating it into a revised order of things. The example I have in mind is the rather obvious one of the transformation of the concept of force or power.

The shift from the mechanistic concept of force to the vitalist idea of active powers can, in one sense, be interpreted as a return to older concepts of matter, part aristotelian, part hermetic. It can also be seen as a turn to and reintegration of popular images and belief into scientific discourse. And finally, as the Roussel statement cited at the beginning of this paper indicates, it was perceived by its proponents as being »revolutionary«, as »challenging established authority«. I would like to argue that all three statements are correct. Further, I suggest that the major actors who effected this »revolution« knew they were challenging more than a specific scientific doctrine: they were challenging the social-political order that it supported.

It has long been suggested and modern research has made it plausible that mechanistic natural philosophy could very well serve the interests of early-modern European absolutism[48]. This was especially true for its concept of power as originating from an all-wise creator

47 Trevor J. Pinch, What does a Proof do if it does not Prove? A Study of the Social Conditions and Metaphysical Divisions Leading to David Bohm and John von Neumann Failing to Communicate in Quantum Physics, in: The Social Production of Scientific Knowledge, eds. Everett Mendelsohn, Peter Weingart, and Richard Whitley, Dordrecht 1977, p. 178.

48 This is the central thesis of Margaret Jacobs' book, The Radical Enlightenment: Pantheists, Freemasons and Republicans, London 1981. In it she expands the ideas of Christopher Hill and Charles Webster to argue that: the founders of modern mechanistic science »lent their support to the established Christian churches of their various societies, and often to the maintenance of established monarchical authority. Western science at its very origins was perceived and used to enhance the power of the ruling élites and prevailing Christian orthodoxy« (p. 31).

or ruler and being imparted to inert matter. What hasn't been so widely recognized is that vitalism could contain a radical message. Too often, it is associated with the conservative and reactionary thought that late nineteenth-century vitalism tended to foster. Or vitalism is simply dismissed as superstition and myth, science gone helplessly wrong. Recent research, however, has shown that seventeenth-century vitalism could and did support radical political and religious movements. It is also clear that vitalism did not disappear from European society, despite the so-called mechanization of the world picture. It was defended throughout the early eighteenth century by a small group of thinkers and more importantly it remained the central constituent of popular belief[49]. There is some evidence to suggest that certain leading figures of the late Enlightenment in Germany, including Thomas Sömmering, Georg Forster, and Johannes von Müller were drawn to alchemy and spiritualism[50]. Thus, the choice to make vitalist arguments was rooted in a tradition still alive and against a background that implicitly challenged the new scientific establishments which were intimately associated with the state. This double movement, one backwards to the period preceding the triumph of »mechanistic natural philosophy« and the other downward to resurrect elements of popular culture, was carried on with a definite aim to establish a new cognitive authority and to dispel those who had dispensed over the old one[51].

Two points appear to support this assumption. The first is the manner in which physiologists and chemists located their activities in the history of their disciplines. As participants in a »new« scientific movement they sought to establish an authoritative history of their discipline in which their work formed the latest and most refined stage of a long process of discovery. In these histories the hermetic concepts of force and power espoused by such thinkers as Paracelsus and van Helmont were evaluated positively, though their »extravagances« deplored[52]. Aristotle and Hippocrates were rehabilitated and often compared very favorably to

49 As far as I know very little work has been done in this area of the Enlightenment. One exception is Rolf Christian ZIMMERMANNS suggestive book, Das Weltbild des Jungen Goethe: Studien zur Hermetischen Tradition des Deutschen 18. Jahrhunderts, 2 vols., Munich 1969–79. However, despite the important insights he offers, Zimmermann still believes the hermetic strains he uncovered to be opposed to the Enlightenment. This can only be maintained if one adopts the traditional view of the Enlightenment as an Age of Reason. An interesting figure to study in this context would be the famous Halle theologian Johann Salomo Semler. By all accounts, Semler is credited as being one of the leading figures in the Enlightenment's reevaluation of theology. At the same time he was a fervent believer in hermeticism and alchemy and in his later life wrote many works defending both. A comparison between his hermetic writings and his earlier theological work shows that the same basic ideas informed both.

50 This is attested to by Rudolf WAGNER in: Samuel Thomas von SÖMMERINGS Leben und Verkehr mit seinen Zeitgenossen, 2 vols, Leipzig 1844, p. 40. »Unzweifelhaft gehen zunächst folgende Thatsachen aus den vorhandenen Papieren hervor: 1) man beschäftigte sich mit alchymistischen Arbeiten, an denen Forster und Sömmering lebhaften Theil nahmen; beide hielten sogar in dieser Zeit es noch für möglich, daß man es so weit werde bringen können, Gold zu machen ... 2) Beide hielten einen Verkehr mit den Todten für möglich, und hofften, auf diesem Wege eine Kenntniss von dem Leben nach dem Tode und andren überirdischen Dingen zu erlangen. 3) Beide geriethen in einem Zustand von Exaltation und religiöser Schwärmerei, indem entschieden in dem Bunde pietistische Elemente waren und ein Cultus stattfand, über dessen Natur nähere Nachweisungen fehlen, in dem es aber auf gewaltsame Gebetserregung und einen näheren Verkehr mit Gott, durch Mißbrauch der christlichen Religion, abgesehen war. Diese Verwirrungen müssen längere Zeit gedauert haben, da der erst später (im Jahre 1782) nach Cassel gekommene Johannes von Müller ebenfalls hineingezogen wurde ...«

51 Arthur L. DONOVAN suggests this in his article William Cullen and the Research Tradition of Eighteenth-Century Scottish Chemistry, in: The Origins and Nature of the Scottish Enlightenment, eds. R. H. CAMPBELL & Andrew S. SKINNER, Edinburgh 1982, p. 105. »The rise of chemistry was part of a broad naturalistic reaction to the politically and conservative interpretation of Newtonianism ...«

52 An example of this is in Gehler's article on chemistry. *Theophrastus Paracelsus ... und Johann Baptist van Helmont ... wandten die Chymie vorzüglich auf die Arzneykunst an, und haben derselben bey*

thinkers of the late seventeenth century who were judged to have had a limited idea of force. In medical tracts, the virtues of popular remedies and practices became increasingly praised and compared to the futile, almost fatal practices of the mechanist physicians. Thus some of the leading vitalist began to question treatments that entailed the dissipation of »vital fluids«. John Hunter, one of Great Britian's leading medical men argued in this manner: *I would by all means discourage blood-letting; which I think weakens the animal principle, and life itself; consequently lessens both the powers and dispositions to action: and I advise being careful not to call forth any disposition that might depress, by introducing things into the stomach, which ordinarily cause nausea ... every such evacuation tending to lessen the animal powers*[53]. Roussel, in a similar vein, argued against blood-letting and purges in cases of pregnancy, asserting that *the pregnant condition can be basically considered as belonging to the sphere of human good health*[54]. What especially annoyed him were male doctors who rushed in and employed mechanical instruments when not needed. Only women weakened by the soft life of luxurious living might need medical assistance, and that assistance was better given by females, who were better able to sympathize with the woman's plight and to win her trust. Animals and rustics have no problems with pregnancy[55]. In some cases this type of position led to a critique of interventionist medicine and research practices and a turn to what we might call holistic medicine. And everywhere – no matter what the specific scientific ideas espoused – the activities of normal, practical men silently plying their craft were seen as more important for advances in specific sciences that the fancies of hypothetical reasoning practiced by speculative philosophers[56].

But even more apparent in delineating this shift in scientific sensibility were the evaluations and metaphors linked to the mechanist and vitalist concepts of power. The metaphors connected to mechanical power were all negative. Associations were made to death, mindlessness, and automatic motion. Mechanical power was seen as that which was dominant in modern armies, in factories, and in despotism[57]. The juxtaposition to active force is drastic. It

aller der ausschweifenden Torheit, mit welcher sie einer Universalmedicin nachstrebten, dennoch nützliche Dienste geleistet. Johann Samuel GEHLER, Physikalisches Wörterbuch, 5 vols., Leipzig 1789–1792[1] I, p. 510.

53 John HUNTER, Observations on Certain Parts of the Animal Oeconomy, London 1786[2], p. 140.

54 Roussel, Physiologie des weiblichen Geschlechts (see n. 4) p. 231.

55 Ibid., pp. 266–271.

56 Ibid., *Inzwischen waren die praktischen Künste des Bergbaues, der Metallurgie, Glasbereitung u. s. w. auf dem zwar langsamen und still, aber sichern Weg der Erfahrung und Ueberlieferung bis zu einer nicht unbeträchtlichen Stufe gestiegen.*

57 In the late eighteenth century despotism was increasingly associated with *»allgemeine Gleichförmigkeit«*, precisely the characteristic associated with inert matter in mechanical systems. Despotism proceeded in a manner analogical to the methods of mechanical natural philosophy. It simplified everything *(»der sonst überall alles simplificirt und gleich macht«)*. It was opposed to a system in which movement was central and communication critical. See Ludwig Timotheus SPITTLER, Sämmtliche Werke, Stuttgart, 1827–1837 XV, p. 363. As Horst Thomé demonstrates, Herder drew the connection between the mechanization of thought and the mechanization of social life. »Ueber den Bereich der Philosophie und Wissenschaft hinaus wendet Herder die Metapher der Mechanisierung auch gegen die Strukturen der politisch-gesellschaftlichen Welt. Technische Erfindungen wie Pulver, Buchdruck und Kompaß, politische Entwicklungen wie die Herausbildung der absoluten Monarchien haben Armee, Wirtschaft und Staat zu stabilen, überpersönlichen Systemen gemacht. In ihn fungieren Menschen nur noch in vorgegebenen Rollen, ohne daß Spontaneität des Handels ermöglicht oder gewünscht würde. ›Mechanisierung‹ des sozialen Lebens stabilisieren einander.« Horst THOMÉ, Roman und Naturwissenschaft: Eine Studie zur Vorgeschichte der deutschen Klassik, Frankfurt 1978 (Regensburger Beiträge zur deutschen Sprach- und Literaturwissenschaft, Reihe B., vol. 15) pp. 327–328. Kant also employed the mechanical metaphor to characterize absolute rule. Peter Burg makes this clear: »In der ›Aufklärung‹ und der ›Kritik der Urteilskraft‹ wird die Maschine als Metapher verwandt, um am absolutistischen Staat Kritik zu üben. Die ›Aufklärung‹ fordert eine Regierung, in der der Mensch

was characterized by metaphors of life, of creation, of striving and invariably associated with the concept of liberty and will. With these formulations we can see how the revised view of nature mutually reinforced the tradition of civic republicanism that became so powerful a constitutient in late eighteenth-century political discourse[58]. An almost perfect example of these motives can be found in the writings of Horace-Bénédict de Saussure, the great Genevian natural historian. His major desire in life was to write a natural history of the Alpine region employing insights developed by Buffon, Pallas, and his friend Abraham Werner. Saussure's special interests were directed to mountain regions rather than to the plains, for the plains were »uniform«, their natural history dull; they no longer demonstrated the active powers of nature. Here Saussure consciously employed those metaphors associated with mechanical power. Mountains, on the other hand, were characterized by images drawn from the life sciences. They demonstrated an »infinite variety« in which the living forces of nature could be observed[59]. Saussure did not stop there, but then drew social consequences from this

›mehr als Maschine ist‹. In der ›Kritik der Urteilskraft‹ wird der ›monarchische Staat‹ als ›bloße Maschine‹ bezeichnet, wenn er ›durch einen einzelnen absoluten Willen beherrscht wird‹. ... Wird hingegen der monarchische Staat ›nach inneren Volksgesetzen‹ regiert, ist er ein ›beseelter Körper‹.« Burg, Kant und die Französische Revolution pp. 176–177. Wilhelm von Humboldt established the same equation between autocracy and mechanism in The Limits of State Action. *Daher nimmt in den meisten Staaten von Jahrzehend zu Jahrzehend das Personale der Staatsdiener, und der Umfang der Registraturen, und die Freiheit ab. Bei einer solchen Verwaltung kommt freilich alles auf die genaueste Aufsicht, auf die pünktlichste und ehrlichste Besorgung an, da der Gelegenheiten, in beiden zu fehlen, so viel mehr sind... Dadurch..., werden die Geschäfte beinahe völlig mechanisch und die Menschen Maschinen; und die wahre Geschicklichkeit und Redlichkeit nehmen immer mit dem Zutrauen ab.* Wilhelm von Humboldt, Gesammelte Schriften, Berlin 18.. I, 126. Humboldt also equated mechanical power with modern military establishments, which he contrasted to earlier »republican« armies where one fought out of a sense of obligation and choice. Here one encounters the merging of the discourse of civic republicanism with vitalist science.

58 Humboldt demonstrates both motives in the discussion of standing armies in his essay »Ueber die Grenzen der Wirksamkeit des Staates zu bestimmen«. *Wenn schon überhaupt der Krieger, mit Aufopferung seiner Freiheit, gleichsam Maschine werden muß; so muß er es noch in weit höherem Grade bei unserer Art der Kriegführung, bei welcher es soviel auf die Stärke, Tapferkeit und Geschiklichkeit des Einzelnen ankommt. Wie verderblich muß es nun seien, wenn beträchtliche Theile der Nationen, nicht bloß einzelne Jahre, sondern oft ihr Leben hindurch in Frieden, nur zum Behuf des möglichen Krieges, in diesem maschinenmäßigen Leben erhalten werden? ... Unläugbar hat die Kriegskunst unter den Neueren unglaubliche Fortschritte gemacht, aber eben so unläugbar ist der edle Charakter der Krieger seltner geworden, seine höchste Schönheit existirt nur noch in der Geschichte des Altertums, wenigstens – wenn man diess für übertreiben halten sollte – hat der kriegerische Geist bei uns sehr oft bloß schädliche Folgen für die Nationen, da wir ihn im Alterthum so oft von so heilsamen begleitet sehen. Allein unsre stehende Armeén bringen, wenn ich so sagen darf, den Krieg mitten in den Schoß des Friedens. Kriegsmuth ist nur in Verbindung mit den schönsten friedlichen Tugenden, Kriegszucht nur in Verbindung mit dem höchsten Freiheitsgefühle ehrwürdig. Beides getrennt – und wie sehr wird eine solche Trennung durch den im Frieden bewafneten Krieger begünstigt? – artet diese sehr leicht in Sklaverei, in jener in Wildheit und Zügellosigkeit aus.* Humboldt, Gesammelte Schriften (see n. 58) I, pp. 138–139. Earlier Herder expressed a similar feeling in his biting way. *Das Heer ist eine gedinkte, gedanken-, kraft-, willenlose Maschine geworden, die ein Mann in seinem Haupte lenkt, und die er nur als Pantin der Bewegung, als eine lebendige Mauer bezahlt, Kugel zu werfen und Kugel aufzufangen. Im Grunde also, würde ein Römer und Spartaner vielleicht sagen, Tugenden im innersten Herde des Herzens weggebrannt, und verwelkt ein Kranz militärischer Ehre.* Herder, Auch eine Philosophie der Geschichte zur Bildung der Menschheit. eds. H. Blumenberg, J. Habermas, D. Henrich, J. Taubes, Postscript H. G. Gadamer, Frankfurt 1967, pp. 74–75.

59 Saussure, Voyages dans les alpes, Geneva 1978, p. ii. This belief that active nature could best be appreciated in mountanious areas also had aesthetic and broader cultural connotations. It served as a support for the emerging idea of the sublime, for the willingness to believe in Ossian and for the whole late eighteenth-century craze for mountain countries, especially for Switzerland where the relation

differentiation. Not only did the mountains reveal the creative forces of nature more clearly, so too did the inhabitants of mountainous regions demonstrate the more noble aspects of human nature. Without overlords, ignorant of luxury, sheltered from corruption, the simple mountain folk, though ruled by superstition were far more admirable than the avaricious »petit peuple des villes«[60]. Mechanical power, both in nature and society, was despotic, active power liberating.

But not radically liberating. Another element of late Enlightenment definitions of active force limits its scope, modifying some of the more extravagant early seventeenth-century visions of vital force. Power was seen to operate within the parameters of polar opposition. Though active power is directional, its path or motion is pulsating. The images of the systole and diastole or of inhalation and exhalation were popular expressions of this belief[61]. Optimal power was achieved within this figurational model in a harmony that mediated between extremes, that juxtaposed consonance and dissonance. This image of harmony differed from earlier ideas of harmony based on the idea of concord. Now, a harmony could only exist through the interplay of dissonances[62]. Thus, in both the natural and the social world the symbol of a static, preestablished harmonic perfection is transformed into one of a perfection in becoming[63]. Harmony is not a condition that is uniform or eternal, it is a goal towards which humans must aspire; it must be fashioned through human endeavor, through a process of individual and social *Bildung* similar to nature's *Bildungsprozeß*. This process is the result of inner activity working upon outer form, driven on by the motor of polar confrontation.

between civic republicanism and wild nature still seemed to exist. In more theoretical terms the tie between the new idea of nature and formal aesthetics can be seen in Karl Philipp Moritzs treatise Ueber die bildende Nachahmung des Schönen, Braunschweig 1788.

60 Saussure, Voyage (see n. 60) pp. ix–x. The assumption that an intimate connection between mountains and freedom was made earlier by Robertson is his History of Scotland during the reigns of Queen Mary and of King James VI, London 1762 I, p. 21. *The nature of the country was one cause of the power and independence of the Scottish nobility. Level and open countries are formed for servitude. The authority of the supreme magistrate reaches with ease to the most distant corners, and when nature has erected no barrier, and affords no retreat, the guilty or obnoxious are soon detected and punished. Mountains, and fens, and rivers set bounds to despotic power, and amidst these, is the natural seat of freedom and independence.*

61 This was especially evident in Goethe's scientific writings, which were based upon the Buffonian-Blumenbachian model I have described. See my article, Bildung, Urtyp und Polarity: Goethe and Eighteenth-Century Physiology, in: Goethe Yearbook 3 (1986), pp. 139–148.

62 The older view of harmony that Leibniz shared emphasized the element of affinity (likeness) and concord. The newer idea propagated in Germany by people like Friedrich Dalberg and Wilhelm Heinse emphasize the interplay between opposites and their resolution. For a clear statement of this position see the two short works of Dalberg: Blicke eines Tonkünstlers in die Musik der Geister, Mannheim 1787 and his Untersuchungen über den Ursprung der Harmonie und ihre allmählige Ausbildung, Erfurt 1800. Both Dalberg and Heinse were very much impressed by the new vision of science. They were in close contact with Sömmering and even used his studies on the organ of hearing to support their positions.

63 Dalberg makes this clear in his description of the creation of great harmonic works in music. *daher sind Dissonanzen, chromatische und enharmonische Fortschreitungen, Mischungen und Verwechslungen nöthig, um den Werth den consonirenden Verhältnisse zu erhöhen. Mannigfaltigkeit in der Einheit; Ordnung und Symmetrie der Theile; stete Abwechslung und Contraste, Kraft mit Anmuth vereinigt – sind die ewigen Gesetzen des ästhetisch Schönen! Willst du wirken und rühren, junger Tonkünstler, so folge diesem Pfade; erwärme dich an dem allbelebenden Feuer, das auch in unsern Tagen einen Bach, einen Hayden, einen Mozart begeisterte! überlasse dich diesem Genius – aber vor allen bleibe den Gesetzen der Natur und des Schönen getreu.* Dalberg, Ursprung der Harmonie (see n. 62) p. 52. The language Dalberg uses here is clearly that of the new sciences, which he applies to cultural and even to political spheres.

There is one more definition of active power that carried a great potential for latent political application. Active power was defined as invisible power. It resided within the organized body and could not be associated with outward form. Power is fluid, it dissolves and hence cannot be associated with any solid, static body, or when displaced into political language with any established elite. Translated into a theory of action, the active powers in the organized body were analogous to the educated intelligentsia, who form a secret society of sympathetic spirits, a *Stand* above the *Stände*. This theory embodies in its very structure both the actual position and the aspirations of that group, especially in Germany where this theory of nature was most clearly elaborated. Excluded from the use of power, they transformed this condition into a positive value. Their social function was to mediate between legislator and legislated through the public use of reason. In effect, the new order of things associated with anti-machanism and vitalism carried a very clear and strong political message: whether looking backward to the republican past where the harmony between man and nature seemed to pertain, to the simple life where a harmony still existed, or to the future where that harmony could perhaps be reenacted on a higher plane, the new order of things emphasized action and freedom of individual choice, limited, of course, by the imperative to avoid what late Enlightenment thinkers considered the plunge into anarchistic chaos. Adam Ferguson, employing the language and ideas of the new science, made this position explicit in 1767. *Our notion of order in civil society is frequently false: it is taken from the analogy of subjects inanimate and dead; we consider commotion and action as contrary to its nature; we think it consistent only with obedience, secrecy, and the silent passing of affairs through the hands of a few: The good order of stones in a wall, is their being properly fixed in places for which they are hewn; were they to stir the building must fall: but the order of men in society, is their being placed where they are properly qualified to act. The first is a fabric made of dead and inanimate parts, the second is made of living and active members. When we seek in society for the order of mere inaction and tranquility, we forget the nature of our subject, and find the order of slaves, not of free men*[64].

64 Adam Ferguson, An Essay on the History of Civil Society, Edinburgh 1966, ed. Duncan Forbes, pp. 268–269. In a work written much later Ferguson used the same metaphors and made the connection between the social order and the order of things more evident. *Parts that constitute the system of nature, like the stones of an arch, support and are supported; but their beauty is not of the quiescent kind. The principles of agitation and life combine their effects in constituting an order of things, which is at once fleeting and permanent. The powers of vegetation and animal life come in aid of mechanical principles; the whole is alive and in action: the scene is perpetually changing; but in its changes, exhibits an order more striking than could be made to arise from the mere position or description of any forms entirely at rest.* Ferguson, Principles of Moral and Political Science I, 66.