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Bertuch did not practice science, although he did understand the craft well enough to fashion a business from it.[1] He was a scientific entrepreneur, who saw the value of free education for skilled workers, graphics for communication, natural history for agriculture, geography for global exploration, and chemistry for sugar beet production. He was an amateur with a nose for the market value of science and technology at a time when the territories of Germany were only beginning to invent research universities that would set new standards for practicing science and increasingly would come to rely on financial support from industries with vested interests in the products of science.[2]

We often tend to view science from an institutional and disciplinary perspective, even when we know institutional research says as much about perpetuating self-similar bureaucracies of academic disciplines as it does about registering the forces that move science.[3] To ignore the market initiatives of the amateur, at that time called a dilettante and today a philanthropist, and

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[1]Henry E. Lowood, *Patriotism, Profit, and the Promotion of Science in the German Enlightenment. The Economic and Scientific Societies, 1760-1815* (New York: Garland, 1991), looks at the role of professional societies in the changing map of German science during the Goethe period, arguing in his introduction that "the founding of new institutions to promote industrial, agricultural, and political progress" was a "pre-occupation" of the Enlightenment, p. 2.

[2]Elisabeth Strauß, Ed., *Dilettanten und Wissenschaft. Zur Geschichte und Aktualität eines wechselvollen Verhältnisses* (Amsterdam: Rodopi, 1994) includes essays from various disciplines, exploring the linkage between the scientist and the amateur with an emphasis on "den vielfältigen Einfluß der Dilettanten im Kontext der jeweiligen Wissenschaft an individuellen Beispielen konkret werden zu lassen, und sie selbst aus der Anonymität der Geschichte zu heben," p. 8.

[3]Lynn K. Nyhart, *Biology Takes Form. Animal Morphology and the German University, 1800-1900* (Chicago: University of Chicago Press, 1995), for example, examines "Morphology as a Theoretical Enterprise" (p. 6), pointing to E. Radl's idealized statement from 1909 that "`German science means universities'" (p. 12), but also noting that "Goethe, who can take credit as one of the disseminators of the word, `Morphologie,' would hardly have deigned to be tied down to a university teaching position" (p. 13).

then to suggest that research institutions drive big science is like saying the actors' guild creates a TV star, the tennis class prepares you for Wimbledon, or German 101 lands you a job with BMW. To examine scientific philanthropy then and now, it seems to me, is to ask about external factors that drive science, much like a dam swells water.[4] Bertuch was an amateur and entrepreneur, but science for him was not just a hobby or a tax write-off, rather it was social, economic, and political and like today, his business supplied resources for the instrumentation of experiments and at the same time supported new industries for trade and commerce.[5]

My question is about the origins of this trend, in which science became big business and at the same time the academy began to separate amateur and professional scientists by rosters and memberships, in the process ignoring the capital gains from industry that have funded science since the advent of modern science itself.[6] One need not be surprised to find answers to this question in Goethe's history of science, and, given the recent publications on his appreciation of sound business habits, it may not be too shocking to suggest that he and others of his generation saw a connection between science, aesthetic education, and the emerging institutions

[4]For the source of the water-science metaphor, see Johann Wolfgang von Goethe, "Der Versuch als Vermittler von Objekt und Subjekt," in: *Die Schriften zur Naturwissenschaft*, Leopoldina-Ausgabe (LA), (Weimar: Böhlau, 1949-), I, 8, 305-15: "Es läßt sich bemerken, daß die Kenntnisse, gleichsam wie ein eingeschlossenes aber lebendiges Wasser, sich nach und nach zu einem gewissen Niveau erheben, daß die schönsten Entdeckungen nicht sowohl durch Menschen als durch die Zeit gemacht worden," p. 307.

[5]For a classical study of scientific materialism in its most radical form, see Karl Marx and Friedrich Engels, "Concerning the Production of Consciousness," in: *The Sociology of Knowledge. A Reader*, Ed. James E. Curtis and John W. Petras (New York: Praeger, 1970), pp. 97-108. They ignore psychological and behavioral habits of the mind and emotions and argue that "the sum of productive forces, forms of capital, and social forms of intercourse" are the bedrock of scientific disciplines. Goethe, too, argued for a contextual development of science, as he had found it in the history of the Paris Academy of Sciences (1635) the Royal Society of London (1660), the former with origins in the business world and the later grounded in centralized government, although he saw the development of science more as a web of various influences, as a "labyrinthine garden" (labyrinthischen Garten, LA,I,6,94).

[6]Thomas S. Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1970 [1st ed., 1962]), more than any other single author opened the door to the study of science beyond its internal consistencies for a sociology of knowledge, a point of view reviewed in Imre and Lakatos and Alan Musgrave, Eds., *Criticism and the Growth of Knowledge* (Cambridge: Cambridge University Press, 1970), which includes a "Reflection on my Critics," by Kuhn, pp. 231-77. See also, Karl J. Fink, *Goethe's History of Science* (Cambridge: Cambridge University Press, 1991), for a study of Goethe's theory of the history of science as an analogue to that of Kuhn, pp. 75-90.

of capitalism.[7]

In Goethe's history of science from 1810, we have an eye-witness account of the origins of tension between "the German big and active world" (deutsche große und tätige Welt, LA,I,6,343-44) with its "support of science" (Verdienste um die Wissenschaften, p. 343), and the "German learned world" (deutsche gelehrte Welt, p. 344) with its "compendia" (Kompendien) and "compendia writers" (Kompendienschreiber, p. 344), especially as this tension unfolded in one of the leading scientific institution in Germany, "the Göttingen Academy" (Akademie Göttingen, pp. 351-52).[8] Goethe saw the narcissism of the academic institution, pointing to its guild-like structure, its litany of formulas and procedures, its tendency to teach with words rather than with objects, to perpetuate illusions of science as a "free operating republic" (freiwirkende Republik," when it often functioned more like "the court of a despot" (despotischer Hof, LA,I,3,291). He saw the way science was driven by the motors of the practical lab, the money of businessmen, and the needs of society, recognizing that the most far-reaching impact on the academy came from the French Revolution, which by 1810 had given every "private individual" (Privatmann, LA,I,6,423) the "arrogance of government" (Regierungsdünkel, LA,I,6,423).[9] Goethe had little faith in the academy as a register of the cutting edge of science and from his vantage point looked beyond the walls of the ivory tower at the business of running a state economy, accommodating the politics of his patron, and sitting on the boards of various

[7]Myles W. Jackson, "Natural and Artificial Budgets: Accounting for Goethe's Economy of Nature." *Science in Context*. 7 (1994): 409-31, offers considerable evidence that Goethe understood the way wealth depended on a "cash flow" tied to material production, and that, as a court administrator, he was influenced by efficient economics both in his literary and scientific work, p. 415.

[8]On Goethe's view of the "ethos of the academy," see Fink, *Goethe's History of Science* (1991), pp. 132-34.

[9]Karl J. Fink, "The Politics of Herder's Pluralism," *The European Legacy*, 1 (1996): 262-69, argues with the metaphor of the snake biting its own tail, that Herder's call for self-determination against Enlightenment standards of progress and success had the effect of supporting indigenous groups by internal measures, but at the same time drove the concept of individual liberty to new extremes of individualism.

business, academic, and government institutions.[10]

In search for Goethe's model of science at the border between education, government, and industry, we have perhaps no better candidate to examine than a fellow citizen of Weimar, Friedrich Justin Bertuch (1747-1822). Indeed, few in the German tradition engaged business in the marriage of science, education, and industry better than did Bertuch. And by today's standards he did fairly well over his lifetime, initiating a dozen ventures abroad with a mixed rate of success, but stabilizing his net growth with at least eight domestic enterprises, of which seven were a success, four of which were passed on to his heirs.[11] Of these four, two made it into the twentieth century, the "Freie Zeichenschule" (Free Drawing School), founded in 1776, and the "Geographisches Institut" (Geographical Institute), founded in 1804. The "Geographical Institute" lasted until 1905, and the "Free Drawing School" was closed in 1930, only to re-open on September 3, 1996, in time to mark two centuries (1776-1996) in the history of one of Weimar's most famous institutions.[12] But what does the "Free Drawing School" have to do with fashioning big science?

With hardly more than the tradition of Cranach's portraits and Bach's compositions, Bertuch won the help of Goethe and the Duke of Weimar-Saxony to open a "free drawing school." It was democratic and open to a public at all ages and stations in life, and it was

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[10]See Johann Wolfgang Goethe, *Goethes Ämtliche Schriften*, 4 vols., Helma Dahl, Ed. (Weimar: Böhlau, 1950-87), particularly volume two which covers the period from 1788-1819, including Goethe's role in shaping staff at the University of Jena. By the middle of the 1960s the arguments for study of the influences on the inner cerebral structure of scientific development had become the central issue in the historiography of science, as framed in popular study guides like the one by George Basalla, Ed., *The Rise of Modern Science. Internal or External Factors* (Lexington: MA: D. C. Heath, 1968), pp. vii-xiv.

[11]See Paul Kaiser, *Das Haus am Baumgarten* (Weimar: Druckhaus Weimar, 1980 [*Weimarer Schriften, 32]*), p. 33.

[12]Shepard B. Clough and Charles W. Cole, *Economic History of Europe*, 3rd Ed. (Boston: Heath, 1952), mark part three of their study of the "Modern Times" with the year 1776, p. 373, the year Adam Smith, in *An Inquiry into the Nature and Causes of the Wealth of Nations* (Buffalo, NY: Prometheus, 1991 [1776]), articulated the basic concepts of capitalism.

pragmatic with a focus on the craft of drawing for general education. Recognizing the demands of an emerging middle class society in search of creature comforts and at the same time recognizing the capital that drives the production of goods for sales across continents and oceans, Bertuch saw an opportunity to wed the arts and crafts with the ingenuity of science and technology for the sole purpose of making money. And viewed through the lens of the history of the Bauhaus at the turn of this century, Bertuch's initiative becomes more than a successful business venture. His goal was to integrate in graphics an act of creativity that attended to the aesthetic and the practical needs of the human being in a changing political and industrial environment.[13] How did he plan to do this?

For the literary scholar, the *Journal des Luxus und der Moden* (1786-1827) is Bertuch's most successful venture, generating capital for other enterprises and lasting five years beyond his death. So what does the journal have to do with "big business in science." Well, everything, although very little by today's categories of deep-hole specialization in the academy. "Everything" if one considers this journal a mark in the transfer of standards of living from feudal to middle class values, new values emerging from the mercantile world of British and French colonization. The journal has everything to with big science when it is viewed as a new medium of communication in which graphics becomes an end unto itself, a medium that would sell itself by marketing inventions of style and technology that fit the cutting edge of tastes throughout the western world.[14]

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[13]Barbara Stafford, *Good Looking. Essays on the Virtue of Images* (Cambridge, MA: MIT Press, 1996, with a passionate defense and embrace of the educative image, argues the demise of the printed word in "an environment that is being "radically altered by volatile visualization technologies," p. 3. She locates the origin of this environment in the "Enlightenment," pp. 20-40: "Eighteenth-century aesthetic and technological innovations, and the visual skills to analyze them, thus have much to teach the twentieth century about the presentation, construction and interpretation of graphical messages of all sorts," p. 24.

[14]Max Horkheimer and Theodor W. Adorno, *Dialektik der Aufklärung. Philosophische Fragmente* (Frankfurt:

For Bertuch the journal did more than display bonnets, dresses, washing machines, shaving tables, buggies and coaches. In it he also marketed the most recent advances in lamp-designs (JLM, 1788, Vol. 3: Tafel 18), in steam power (JLM, 1799, 14:15), in electric lighting (JLM, 1800, 15: 9), and in running hot-water systems (JLM, 1803, 18:30), in all of this processing information rather than manufacturing products.[15] Indeed, in the "Advertisement Page" (Intelligenz-Blatt) for the May issue in 1790 (JLM, 5:ix), Bertuch listed sample sheets of different printing fonts with variations at least as great as those offered in every home and office computer today.[16] This *Journal*, Bertuch's second venture, would have to be deemed a success, not only by longevity and capital gains, but by measures that link the urge of consumerism to the technology of production, and fourthly by seeking in graphics itself a medium for processing information for money. Bertuch started with community education in graphics in 1776, in 1778 he bought a paper mill and a dye factory, and with a few departures like his artificial flower factory, where Goethe's wife was employed, Bertuch stuck to the straight and narrow path of graphics. He stuck to what he knew best and that was to science and technology with a nose for the graphics that promoted the tastes of an emerging consumer. In the end he built an industry that was designed to sell information.[17]

Fischer, 1969), argue in their chapter on the "Culture Industry. The Enlightenment as Mass Deception" (Kulturindustrie. Aufklärung als Massenbetrug, pp. 108-150) that the homogenizing and normalizing effect of the entertainment industry began to shape modern society in the Enlightenment period and took its most radical form in the barbarism of the Nazi era (pp.122-125).

[15]See Thomas Föhl and Michael Siebenbrodt, *Bauhaus-Museum* (Weimar: Deutscher Kunstverlag, 1996, where the table lamp of Carl Jakob Jucker and Wilhelm Wagenfeld (1923-24) becomes a symbol of Bauhaus innovation with materials and design.

[16]Stafford, *Good Looking* (1996), seeking connections that link "the internet to Eighteenth-Century Laboratory Life," pp. 90-110, argues that "Pixels are our movable type," that, while the eighteenth-century witnessed the "disintegration of congealed categories" and the "collaging of disparate media," it was limited in its ability to cope with "dynamic phenomena," p. 94. Bertuch's multiple fonts would suggest otherwise, as would Goethe's study of form as movement, Ronald Brady, "The Causal Dimension of Goethe's Morphology," *Journal of Social and Biological Structures*, 7 (1984): 345-56.

[17]See Stafford, *Good Looking* (1996), on "The knowledge Business," pp. 107-110, or for broader statements on

In the wake of the French Revolution, Bertuch merged his various enterprises into a single corporation called the "Landes-Industrie-Comptoir" (LIC) in 1791, arguing in an essay two years later (JLM,1793), that "industrial institutions" (Industrie-Anstalten, 1814, i) should be supported by the princes in the national interests of all Germany. Particularly states like Saxony, he wrote, would benefit most from a "state economy" (Staats-Oekonomie, 1814, iii). What Bertuch feared most in the post-revolution tensions in Europe was the radical changes driven by what he called "the speculative spirit of British and French manufactures" (Speculationsgeist der Englischen und Französischen Fabrikanten, 1814, iii). The threat from abroad, he argued in the preface to a second edition of the essay published in 1814, gradually would "suffocate" (ersticken, 1814, iii) budding enterprises such as his LIC and undermine all chances of securing Germany's "old trade monopoly" (ihres alten Handels-Monopols, 1814, iii). His evidence was the comparative trade statistics on German-French-British exports and imports, and it was on this basis that Bertuch argued for protecting ventures like his own with investments in science for business.

In some ways the "Free Drawing School" and the *Journal der Mode und Luxus* were a natural fit for Weimar with an emerging middle class of 6000 inhabitants. Accustomed to bureaucratic security that goes with any government town, the community was open to development of the fine arts, even without artisans and craftsmen of graphics typical of other German cities. Bertuch's was a clever plan, a public school to train a whole community in the graphic arts, the underpinnings of his vision of business supported by science. This plan

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the potential of graphics in science technology, see Howard Rheingold, *Virtual Reality* (New York: Simon and Schuster, 1991), who opens his discussion of "The Reality-Industrial Complex" with the observation that casts graphics at the center of the knowledge business: "As the processing power and graphics frame rate on microcomputers quickly increase, portable, personal virtual environment systems will also become available. The possibilities of virtual realities, it appears, are as limitless as the possibilities of reality," p. 131.

gradually gave him the wealth needed to build a house and property in Weimar, which Friedrich Schiller (1759-1805) praised for its blend of aesthetics, country living, and sound business: "He lives outside the gate and has without a doubt the most attractive house in all Weimar. It is built with taste. . . . Adjoining is a garden, not much bigger than a Japanese garden, which is divided into seventy-five plots, each of which brings in one to two dollars per year.[18] Schiller, the author of "aesthetic education," in which life is guided by efficacy, by discipline and competence with a quality free from the constraints of the market place and the cathedral square.[19] So how did Bertuch probe the fit for marketing science in Weimar, which at that time had little more to offer than a tradition of ducal patronage for the fine arts?[20]

One of the first enterprises of the LIC was map production, a business fed by the needs of global expeditions in an "age of discovery,"[21] and one that required both educational and financial investment beyond the experience of the inhabitants of Weimar. Bertuch began his cartography production in 1791 and by 1804 it grew into an organization with a corporate identity separate from the LIC, which survived until 1905 as the "Geographical Institute" (Geographisches Institut). He began with five printing presses in 1786, which were used mostly for publishing the etchings, prints, reprints, and various graphic forms for his literary projects. In

[18]Friedrich Schiller, "An Körner, August, 1787," in: *Schillers Werke*, Nationalausgabe (NA), 42 volumes Ed. K. H. Hahn (Weimar: Böhlau, 1943-), marvels at Bertuch's ability to blend financial gain with aesthetic living: "Er wohnt vor dem Thore und hat ohnstreitig in ganz Weimar das schönste Haus. Es ist mit Geschmack gebaut, . . . Nebenan ist ein Garten, nicht viel größer als der Japanische, der unter 75 Pächter vertheilt ist, welche 1-2 Thaler jährlich für ihr Pläzchen erlegen. Die Idee ist recht artig, und das ökonomische ist auch dabei nicht vergessen," vol. 24, p. 136,

[19]Schiller, "Über die Ästhetische Erziehung des Menschen in einer Reihe von Briefen," in: *Schillers Werke*, Nationalausgabe (NA), (Weimar: Böhlau, 1943-), Vol. 20, pp. 309-412, locates aesthetic education in the bio-psychological function of "play" (Spiel, 406-10), in this visceral level of life requiring freedom from the spiritual and material demands of life.

[20]Reiner Schlichting, Ed., *Genius huius Loci Weimar. Kulturelle Entwürfe aus fünf Jahrhunderten* (Weimar: Stiftung Weimarer Klassik, 1992), begins his history of the genius of Weimar with a chapter of exhibitions "Von Cranach bis Bach," pp. 9-33, setting the stage for a history of Weimar graphics.

[21]See Lynne Withey, *Voyages of Discovery. Captain Cook and the Exploration of the Pacific* (Berkeley: University of California Press, 1989).

1803, he added six more presses and in 1819, three years before he died, he added three more, with each addition responding to the latest technology in printing with metals, stone, wood, and ceramics. The best estimates of critics is that by 1819, Bertuch had achieved a graphics potential in the small town of Weimar equal to that of the metropolitan populations of Berlin (145, 000), Vienna (210, 000), Nürnberg (30, 000), and Augsburg (20, 000). In this environment, Bertuch found advantage in locating all production in Weimar, not "out-sourcing" for craftsmen, not risking transportation damage to sensitive copper plates, in general competing by localizing training and production.

The "Geographical Institute" was Bertuch's most successful venture in the big business of science. But there were others, some even more innovative but clearly ahead of his time. One of these was to develop a school curriculum that would train students in the use of natural history for practical life, an idea expressed in the title of a book from 1799: "On the means to make natural history generally useful and to introduce it in practical life; along with a syllabus and announcement of a series for the intended work" (Über die Mittel Naturgeschichte gemeinnütziger zu machen und in das practische Leben einzuführen; Nebst Plan und Ankündigung einer Folge dahin abzweckender Werke, 1799).[22] With the marriage of curriculum, science, and industry in mind, he argued that "no one denies any more the general influence of the knowledge of natural history on farming, manufacturing, trade, the arts and crafts, and state and private businesses" (Niemand läugnet zwar mehr den allgemein-wichtigen Einfluss, den Kenntniss der Naturgeschichte auf Landwirthschaft, Manufacturen, Handel, Künste und Gewerke, Staats- und Privatwirthschaft hat," 1799,3). How did Bertuch justify such a

[22]According to Paul Kaiser, *Das Haus am Baumgarten* (1980), Bertuch became a member of the "churmainzische Academie nützlicher Wissenschaften zur Erfurt" in 1778, in 1816 becoming Director of the organization, p. 102-03.

venture at a time when there was no curriculum, little government-business linkage, and no experience with the cost-effective production of knowledge?

In his book on resources for making a business out of natural history he followed typical steps for writing grant and course proposals today, including objectives, rationale, and samples with outcomes, but also adding a list of obstacles to his proposals. In his objectives and rationale, he argued for a new environmentalism, which he argued would not be a religion of "stupid piety, nor of emotional mysticism" (stupider Frömmeley, noch schwärmerischer Mystik), rather a religion of "true feelings of the heart" (Herzensgefühle) which would bring with it a truer "morality" (Moralität), a truer "culture" (Kultur) and a more genuine "enlightenment" (Aufklärung, 1799,5). In his third rationale for popularizing "natural history" he hoped to ban practices harmful to the land, in the fourth to find improved use of "local natural products" (einheimischer Naturproducte), in the sixth to "save the birds" (Nichtausrottung aller der Vögel), and in the seventh to advocate "animal rights" (bessere Behandlung nützlicher Hausstheire, 1799,6). In general Bertuch sought a market for green peace "by promoting satisfaction with the location and station in the life of the ordinary man, and by stimulating his industry with better order and consequently with better results" (Durch Beförderung der Zufriedenheit des gemeinen Mannes mit seiner Lage und Stande, und Belebung seiner besser geordneten und folglich auch bessere Resultate gebenden Industrie, 1799,6). Here he hoped for more than turning a buck, he hoped also to save the land with a science that satisfied the public.[23]

In the second part of his proposal, Bertuch examined the obstacles to popularizing natural

[23]Stafford, *Good Looking* (1996), locates this kind of "information ecology" in the second half of the eighteenth century: "virtual pedagogy placed a premium on generating ever more convincing illusions," p. 98. In Charles Rabinqueau, a French entrepreneur, she finds one of a breed, "devoted to exhibiting the latest fads, gadgets, games, and experimental novelties," "communicators," who "traded in their ability to reveal, to make hidden phenomena disclose themselves," p. 101.

history for public use, and in part three he proposed seven resources with which one could overcome all these road blocks to the use of natural history. Most resources were some form of investment in education, but he was putting his best bet on number three, in which he listed thirteen requirements needed for the professionalization of the technology and production of graphics. Here he proposed "Illustrations" (Abbildungen, 1799,17) for all three realms of natural history (plants, animals, and minerals) and with this plan he hoped for "the symbolization of all of natural history" (Versinnlichung der ganzen Naturgeschichte, 1799,17).

Bertuch's goal was to build the foundations for a syllabus "of impressions through the eye" (von bildlichen Eindrucke durchs Auge, 1799,17), and the list of thirteen requirements needed to achieve this goal read like a graphics style sheet designed for a modern sales catalog. This was a business venture, which required above all that the work "must appear periodically so that the less affluent amateur might purchase it in regular small payments; but it also must appear quickly so that it becomes useful" (Das Werk muss periodisch erscheinen, um dem wenigerreichen Liebhaber nur successive kleine Zahlungen zu machen; aber auch schnell, fortschreiten, um bald brauchbar zu werden, 1799,18). In these plans for regular installments of visual material, produced by the professional for the amateur, we have the transition into not only modern science, but the modern age of media industries.

But all was not just business, some was intended to be science as we find in the seventh resource for making money with natural history. Here he proposed "small topographical natural collections. . . for the explanation of local natural products of cities, villages, and regions" (kleine Topographische Naturalien-Sammlungen . . . zur Erklärung der localen Natur-Producte der Stadt, des Dorfes, der Gegend, 1799,24). Indeed, here he devised a plan by which the local farmer as well as the apprentice could make contributions to the search for natural products

guided by the professional scientist. This proposal was ingenious in its conception, at the same time calling for the visualization of natural products, for local and regional participation, and thirdly, for a framework guided by a school system linked to industry through apprenticeships,

The venture to make money from natural history was Bertuch's most successful failure. His first attempt to realize money from natural history appeared in 1810 in E. Dalton's *Naturgeschichte des Pferdes* (Weimar: LIC, 1810), a single oversized volume on the history of the horse done with exquisite plates and explanations of the origins and distribution of the horse around the globe. Indeed, it is a phylogenetic illustration of the most useful natural product to grace the age of global discovery, showing at the same the purpose and scope of Bertuch's project and the cost-effective limitations of graphics for science. The graphics are excellent, but the book is cumbersome, bringing more art than commerce to the venture in natural history.

Bertuch's scheme to professionalize natural history did not materialize exactly as envisioned. But that did not mean he could not make money from illustrations in natural history, which he did by publishing his prints in a series of "Picture Books for Children" (Bilderbuch für Kinder, Weimar: LIC, 1790), which in 1802 was already in its fourth edition. Here he found a home for his interests in natural history, especially in botany, by one critic's count, producing 1185 copper plates, which he published in twelve volumes with twenty-four companion volumes of text for a total of 3000 copies.[24] Here was a collection of plants, animals, minerals, flowers, costumes, and exotic images that captured the interest of consumers eager to buy books about nature and culture abroad. And the genius of the enterprise was to respond to human curiosity with new visual technologies.

There were other ventures in which Bertuch looked for business in science, linkages

[24] Kaiser, *Das Haus am Baumgarten* (1980), p. 59.

which in his scheme of things always required training and curriculum. Indeed, if he were to drive the Autobahn from Hamburg to Munich, he would be surprised at the success of his most far-reaching proposal, the introduction and production of sugar-beets in Germany as a "surrogate" to "colonial goods" imported from abroad. Armed with import-export statistics, he published an "Overview of Colonial Goods from Abroad, Along with Domestic Surrogates in the Plant Kingdom" (Übersicht der ausländischen Colonial-Waaren, und ihrer inländischen Surrogate aus dem Pflanzen-Reiche, Weimar: LIC, 1812). Here he listed eleven domestic sources of sugar, in a process of elimination for business and technical reasons concluding that the best potential was in the "white beet" (Runkelrübe), at that time hog feed, today grafted into a sugar beet industry that followed Germans from the Volga river in Russia to the Platte river in Colorado.

Bertuch probably never planted a "Runkelrübe," probably never dug one out and probably never carried one to the factory, but in his overview of different surrogates for agricultural development, he gave this one the most attention, publishing the results of experiments on natural products for industrial development, concluding that he preferred the research of Professor Göttling from Jena, who successfully had processed dried beets, which meant that production could be spread across seasons and regions. Dry processing had the further advantage that burning costs would be reduced significantly and that the chemical process of turning beets into pure sugar crystals would be more efficient. What he liked most was that Göttling was no "theoretical speculator" (theoretischer Speculant), rather a "splendid applied chemist" (ein trefflicher practischer Chemiker): "What he has written, he already has examined with care." (Was er schrieb, hatte er vorher sorgfältig selbst probirt. 1812, 49).

Bertuch, living in the age that discovered basic principles of capitalism, turned graphics

into an industry by integrating traditional arts and crafts with science and technology and by offering the products of this union to a population that was beginning to define its middle class values. He argued for an improved standard of living, for more coffee for breakfast, for home improvements like shaving stands, running water, and steam heat, looking for the best that science and technology could bring to the home of the modern consumer. Without apology, he promoted the practical advantages of a high standard of living, arguing for national protection of German industries, for a marriage of business, government, science, and education. At the center of his business ventures were graphic images of an improved standard of living supported by science and technology, as in his announcement of "The electric light machine" (Die electrische Licht-maschine, JLM, 1800, 15:159-61): "Who would have believed, after the immortal Franklin taught us to capture lightning and to conduct it at our pleasure, that we would be so bold and would add a small lightning machine to our household appliances."[25] This was the dawn of a tradition that would be revisited a hundred years later in the "Bauhaus" with its new designs for the integration of life and technology that followed the industrial revolution at the end of the nineteenth century.

CONCLUSION

We still live by Goethe's model of science, relying on entrepreneurship to drive science inside and outside the walls of the academy and accepting the tension and ambiguity between certification and philanthropy. We continue to do business as usual, indeed, more than ever entrepreneurs are blurring the lines between certified professionals and active amateurs. Bill Gates is not a professional by academic credentials, but probably has influenced science, or at

[25]Bertuch, "Die electrische Lichtmaschine," *Journal des Luxus und der Moden*, 15 (1800): 159-61, "Wer hätte glauben sollen, daß wir, seitdem uns der unsterbliche Franklin lehrte den Blitz auffangen, und nach unserm Gefallen leiten, so kühn seyn würden, uns kleine Blitzmaschinen zu unsern Hausgeräthe zu schaffen," p. 159.

least a scientific way of thinking inherent in the computer, as much as did Einstein, who himself struggled for a degree and took his first job outside the academy. It would be hard to envision the big science of Einstein without the big dollars of Gates, and even more interestingly, both seem to be an enigma of the academy, the citadel of standards, certification, and progress.[26] In our world, too, in the ordinary world of learning, we continue to function like they did in Goethe's day, tied to certification by the academy with hopes for occasional subsidies from a patron of big money. Have you found a "sponsor" for your next project?

[26]Temple Grandin, *Thinking in Pictures, And other Reports from my Life with Autism* (New York: Doubleday, 1995), argues in a chapter on the "Link between Autism and Genius," pp. 174-88, that beyond Gates and Einstein, others like Wittgenstein, were touched by the abnormalities of autism, and that they shaped the brain with habits of compensation, including primarily techniques of visualization: "He told his psychologist friend Max Wertheimer, `Thoughts did not come in any verbal formulations. I rarely think in words at all. A thought comes, and I try to express it in words afterwards,'" p. 182-83.