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GEORGE SARTON CHAIR

of the

HISTORY OF SCIENCES

2005-2006

SARTON CHAIR LECTURES

Laudatio Lewis PYENSON

Fernand Vandamme

In 2005, we have the 18th time that the Sarton Chair is awarded. The first chair was attributed to Prof. Merton. He was one of the rare students and collaborators of George Sarton. Moreover Merton was an outstanding creative and original scientist in the history, sociology and science of science. This 18th Sarton Chair is again awarded to an intimate of Georges Sarton, but rather an indirect intimate. He is a scholar and researcher, who studied intensively the Sarton family: George, his wife Mabel Sarton and his daughter May Sarton. He got some strong direct contact and information from May Sarton, to better understand the cultural environment and "niche" of Sarton and his way of living, thinking and working. But what is even more striking, Lewis Pyenson in many ways is a character strongly mirroring George Sarton. He is a humanist, targeting to do his scientific research, including the history of science, like Sarton did, in view of supporting, stimulating the cultural and social progress of mankind.

Like it was the case with Sarton, Lewis Pyenson, sacrificed a lot to his high moral and social standards, his integrity, not compromising for the sake of personal benefits, his principles in view of stimulating progress in knowledge for the sake of creating a better mankind, a better world.

In the European-American-Asian tradition of critical knowledge development against conservative statusquo, Lewis Pyenson like Sarton choose in a way for action oriented creative innovation. The bibliometry created by Sarton was such a clear action oriented approach. So was also Sarton's peace oriented perspective. So clearly described and synthesised already in a rather youth publication of Sarton (republished by M. Thiery in Sartoniana). In this article Sarton described the importance of the efforts in favour of antiviolence development of knowledge and human dignity in the perspective of Tolstoï. Today we probably would refer to Gandhi, although the antiviolence approach of Tolstoï goes much further even than Gandhi or Luther King. We can refer here to Sarton, mirrored by Pyenson as a philosopher, a historian, which is an initiator to scientific, cultural, social integration of knowledge for community development.

In this Sarton was probably a catalyzer of this tendency in the first half of the 20th century, but at the same time, with strong methodological orientation and with his holistic perspective, he was formulating de facto crucial targets for the 21st century.

In the same spirit and perspective, we see Lewis evolving. He organizes series of colloquia relating education and research, relating specific disciplines and interdisciplinary etc. All themes so dear to George Sarton. His engagement as scientist as well as humanist (interrelated) comes also distinctly clear in his engagement concerning the independency of the university from the military in their selection of students. This issue is still today dividing the U.S. Already in 1992 he preferred to quit as a dean rather than to execute a policy which contradicted his humanistic, scientific values. For sure, also in his scientific, historical and philosophic work Lewis is outstanding. In the first place we have his enormous relevant work on George Sarton. Besides he publishes a lot of articles and books in the domain of history of sciences. Moreover he plays in this domain an important role as manager and guard. He is member of redaction committees, of advisory committees on a lot of important journals or book series (in fact 13) related to the history of sciences.

Concerning Lewis Pyenson's work on George Sarton, we like to refer to his most recent work "The passion of Georges Sarton: A modern Marriage on its discipline". In this work, Lewis bridges Sarton's professional life and his private life.

Moreover Lewis has also paid a lot of attention to the study of Sarton's perspective of the origin of the modern scientific methods and its debt to the Islamic Culture. Sarton, together with Duhem, belongs to the first historians who have criticised the traditional but wrong view that modern science was a product of the renaissance. Both Sarton and Duhem have independently of each other recognised that scientific relevance of the Renaissance in general and Da Vinci in particular is not existent. The first modern science, which combined theoretical, mathematical description and analyses, with experiments, based on invention of new tools (through ad hoc adaptation of old ones) we found in the Islamic culture (8-12th century). Through Scholastics it generated the crucial Western Science of Copernicus, Galilei, Harvey, Colombus and so many others. The University of Padua was the pivot in which mainly under the lead of the methodology chair in the hands of a series of eminent medics, created the modern Western science tradition.

This discovery was in itself already an enormous achievement of Sarton. It is again a nice example how the so called different cultures are much deeper imbedded and interlaced with each other, not only with its Mesopotamian roots, but also in its much more recent developments. This illustrates that the cultural dialog in view of progress of humanity and its sustainability in its different dimensions are so important, as the endeavours of Tolstoï, Sarton but also Lewis Pyenson in their professional as well as personal life so courageous have illustrated again and again.

DISCIPLINE OF A MARRIAGE: THE SARTONS MAKE HISTORY OF SCIENCE

Lewis Pyenson

We live in the Age of Swine, James Surowiecki observed recently in the *New Yorker*. More precisely, the swinish self-interest behind free-rein capitalism now turns the world. People risk venture capital on technological innovation, presumably in addition to investing in stock and real-estate scams, in the exportation of manufacturing and services beyond the reach of minimum wage and regulated working conditions, and in questionable enterprises like spamming and the narcotics trade. Surowiecki summarizes: In the dreams of avarice lie the hopes of progress.(1) There is certainly plenty of swinishness to go around these days, but self-interest is nothing new. One nineteenth-century observer of economics even placed it at the root of revolution against capitalism. Enlightened self-interest, Karl Marx insisted, is a precondition of revolutionary socialism.

A more accurate designation for our time is the Age of Whine. We are deluged with accounts of personal misfortune, so much so that a genre of literature called self-help has emerged to serve sufferers of clogged arteries, flabby midrifts, and phony investment portfolios, to mention only a few classes of aggrieved reader. Autobiographical tales of open-heart surgery and stock swindling, by talented writers with no claim to motivating historic events, rise to the top of the sales charts. We admire poets of whine, who are able to transmute their sickness into art.(2) We venerate the ones who choose to check out of life early. In an Age of Swine, people are dying to live; in an Age of Whine, people are living to die.

To judge from the pages of the weekly American journal, *Chronicle of Higher Education*, whining is widespread in the academic life. Professors whine about money (athletic teams get too much of it, specialist journals are too dear); they whine about nepotism (the provost hires his drinking buddies but won't employ their husband or lover); they whine about resources (crummy library, antiquated particle accelerator). Seldom appreciated is the structure behind the whining. Many professors are permanently located at institutions where even stray dogs hesitate to take up residence, and it has been so for more than a hundred years. Sociologist Max Weber emphasized in 1919

that academic life is a wild gamble, where material rewards are attributed whimsically, and where only a rare spirit can maintain equanimity in the face of the consistent promotion of mediocrity.(3) Unlike today's journalistic whiners, Weber deals at length with the connection between a scholar's emotional state and his calling, with why the self-effacing and ineluctable belief in the superannuation or progress of knowledge should animate teachers. But neither Weber nor the whiners consider how a scholar's intimate domestic situation may determine his scholarly accomplishment. In one form or another, love does make the world go round. I address the topic here by considering the love of George Sarton.

Love and devotion animate the past, and not only where the beloved is a passive object of desire. There are writers and artists: Héloïse's Pierre, Emilie's Voltaire, Virginia's Leonard, Frida's Diego, and Sylvia's Ted. We would live in a gray and horizonless present without the evocative creations inspired by eros, the Belgian philosopher Suzanne Lilar emphasized nearly half a century ago. In her great work of 1963, *Le Couple*, she champions the cause of *unreasonable* love, going against the principal affliction of the twentieth century, the demythologization that attacks all values. She speaks for a whole and responsible love now possible for the first time in history. In Lilar's view, love is self-conscious and reflective: A great love is above all an awareness of a deep-rooted *nostalgia*, which it passionately tries to satisfy. This, whatever may be thought to the contrary, presupposes a strong sexuality, a motive power capable of assuring communication, able to join as well as to transport. Lilar begins her enquiry with the marriage of Peter Paul Rubens and his different wives, Isabella Brant and Hélène Fourment, following the inspired discussion of Eugène Fromentin.(4) George Sarton, who grew up in Ghent next to a Rubens painting in the Cathedral of St Baafs and who took his early literary *nom de plume* from a novel of Fromentin's, made love the center of an academic discipline.(5)

To describe those infected with love today, we would need a list where the possessed and the possessing are interchangeable, for we see the partners in a marriage as intellectual and financial equals. The equality has been achieved in the world of capitalism under the intense pressure of a persistent communist model stretching from medieval times through the English, French, Russian, and Chinese revolutions and with elaboration by millenarian communities elsewhere. The achievement has not been without strain. The latest census reports indicate that most adults are married, but it suggests that a substantial portion of this group are not happily married. About half of all marriages result in divorce; a large number of the remaining unions suffer estrangement; most married couples, it seems, are unfaithful to each other.(6)

When did the modern pattern, with its new sensibility, emerge? Demographers have mapped the precipitous decline in European fertility as a way to trace modernization across the nineteenth and twentieth centuries; the decline, they conclude, is based on birth control women's empowerment over their own body.(7) Freed from perpetual child-rearing, ordinary women could become industrial workers or, more optimistically, imitate the aristocracy by studying nature and writing poetry. Whether women's political rights, no less than the spread of birth-control techniques, trickled down from the highest levels of society or percolated up from the lowest, at the end of the nineteenth century women entered institutions of higher learning in substantial numbers, and they often married for love fellow students. Formed in women's secondary schools by talented teachers unable to obtain a university position or to live on a university salary, young women *circa* 1900 learned to wield the instrument of reason. The intellectual firmament early in the twentieth century displays a large number of binary stars: the Einsteins (Mileva and Albert), Curies (Marie and Pierre), Ehrenfests (Tatiana and Paul), Clays (Tettje and Jacob), Webers (Marianne and Max), Webbs (Beatrice and Sidney), and Woolfs (Virginia and Leonard).(8) The marriage of George Sarton and Mabel Elwes Sarton, which led to a continuing tradition of scholarship, is exemplary of these complex and sometimes unstable unions.

The domains of intellectual accomplishment in the Sarton marriage are decorative arts and history of science. The decorative arts intended to allow sensitive design to enter the life of laborers and farmers, whether in fabrics, wall-hangings, domestic utensils, or furniture; for better or worse, the interior of our homes today owes much to these disciples of William Morris. History of science, an established if fractious department of higher learning, emerged to celebrate industrial progress (the very notion of progress depends on a recapitulation of the past) and also to organize and analyze the contents of enormous museums and more particularly libraries that had come into being over the generations before the First World War; we still hope for new gadgets and medical cures, and, for better or worse, few scholars today can completely avoid the shadow cast by the Harvard College Library or the Louvre. Among the general reading public, Mabel and George Sarton are known as the parents of the feminist poet May Sarton, who has written eloquently and evocatively about them and their times.(9)

Manifestly no Macaulay, is the assessment of George Sarton by two of his biographers, who identify his legacy in the creation of tools, standards, and critical self-awareness in a discipline.(10) Mabel Sarton's designs and creations can be found in great collections, notably the Smithsonian Institution and the New York Public Library, but her name is associated with no

particular motif or structure. It is more reasonable to contend that the Sartons are original creators centrally situated in major cultural currents. Equally significant is the emotional side of their marriage. Even if their intellectual accomplishments had been dimmer, their affection testifies to the emergence of a new pattern of family life, the effects of which are felt for much of the twentieth century.

The story of the discipline of history of science is anything but dull reading. There are colossal errors of administrative judgment (regarding Paul Tannery's candidacy at the Collège de France); there are prisoners of conscience (Bertrand Russell and Lancelot Hogben incarcerated for war-resistance in England and Dirk Struik for holding the wrong political opinions in Boston); there are infelicitous political compromises (the aged Karl Sudhoff's membership in the Nazi Party); there are travel restrictions East and West (notably concerning Joseph Needham, for many years denied a United States visa); and there are stories of wandering exiles (the mathematician-thief Guglielmo Libri was one, and in a different vein Aldo Mieli and Alexandre Koyré were others).(11) The themes of politics, pacifism, and penury are writ large across the life and the purpose of George Sarton, animator of the disciple in the United States.

Not only did George Sarton animate the discipline of history of science in America, he dominated it. For more than half a century, much of its activity derived from his large vision of humanity, as well as from his anxieties and personality. His early programmatic statements as well as his popular writings that is to say, a majority of his writings before the late 1920s were designed to attract funding to his enterprise and to secure a better position for himself and his family. From the time of his youth, George claimed to privilege his studies over his family, but his family is embedded in his work. Mabel Sarton, in particular, was the agent of George's success. Her kind and sympathetic social sense acted as a counterweight to George's impulsive and abrupt manner. Contacts made through her business in design helped secure George's lifetime post with the Carnegie Institution.(12) The birth of George's discipline required both husband and wife.

George Sarton was raised without religion in Catholic Ghent. By virtue of her own ethical-religious training in the London congregation of the American émigré pacifist minister Moncure Daniel Conway, Mabel Sarton was able to establish strong connections with the American Protestant Establishment who supported them both. Mabel writes from London on 6 April 1899 to her friend Céline Dangotte:

I want to tell you that we hardly *ever* go to what you understand by a church. We belong to a society called

> South Place Ethical Society. They have a building which is called a chapel but is not at all like one, at Finsbury in London. On Sundays there is a service. No prayers, no regular sermon. The service begins by singing something, not like the hymns in ordinary churches but poems in which the great idea is of One Supreme Being & of universal love & fellowship *on earth*, without expecting you to believe in a conventional *heaven*. After the singing something is read from some book on religion, not only *Protestant* but Roman Catholic, Buddhism or any other where pure & holy thoughts are contained. Then an anthem is sung (always by professionals, they do it for nothing). Then there is the lecture or sermon. Every Sunday it is a different man, or nearly so, any-one who has something worth saying may lecture & it is on all sorts of creeds & religions.(13)

The South Place spirit remained important in Mabel's life; it is possible, for example, that she heard the lectures of John M. Robertson in 1891 on, among others, Thomas Carlyle and John Ruskin, both of whom early influences on her thought.(14) She later writes to her mother from Ghent: I have been looking through the S. P. Magazines I have. I want to have them bound a little later. I find I have not any year complete (not even with those Cé[line] had). The following nos. are missing. If you find you have them twice, any of them, let me know.(15) George Sarton obtained Conway's book, *My Pilgrimage to the Wise Men of the East* (Boston, 1906), soon after he married Mabel in 1911, and he credited the book with awakening his interest in things Oriental.(16)

George Sarton liked to think that two children were born to him in 1912, daughter May and his history-of-science journal *Isis*. He honored Mabel as their mother. The name of his journal was chosen by them both. In our earnest innocence, he writes in his biography of Mabel, we had conceived something immortal,... which deserved to bear the name of an eternal goddess.(17) The first number of *Isis* is dated March 1913, but George observed that he circulated a prospectus of 50 pages somewhat earlier, and his programmatic announcement of the journal appeared in November 1912. To call May and *Isis* 'twins' is thus inaccurate though they were separated by an interval (six months) too short for ordinary sisters. George recalls that he and Mabel sent out thousands of copies of the specimen number to scholars identified from the pages of the annual academic directory, *Minerva: Jahrbuch der gelehrten Welt*. I wrote the addresses, Mabel did the wrapping and added the stamps.(18) Years later, Mabel designed a bookplate for George, and elements from it were incorporated - not without bowdlerized modification - by George's successors on the masthead of *Isis* and publicity for the History of Science Society. The discipline carried his name and her art to the end of the twentieth

century.(19)

George's purpose emerged when he was a student engaged to Mabel Elwes. She was a penniless English artist, alumna of a distinguished girls' school in Ghent, in effect adopted into the home of a wealthy interior designer in Ghent.(20) George writes to his betrothed on 28 October 1910, affirming the sense of their union. I am one of those who believes that great scientists and great artists, great thinkers and great musicians, great dreamers and great doers, live in the same atmosphere, *breathe the same air.* I am one of those who think that the enterprise of science is an enterprise of art. I do not think it only, *I sense it,* with all my being, all my nerves tell me that. When he reads a treatise on geometry, he hears an orchestra playing. I know that art and science are identical, just as I know that I exist. The two, when they are beautiful enough, produce the same enthusiasm, the same frenzy, the same sacred intoxication, the same rhythms, the same thrills. He continues:

> Later, in a hundred years, recognition will perhaps come, if I succeed to accomplish it, the artistic value of my work. And it requires as much imagination & inspiration to reconstitute the past, penetrate the thought of other times & write the history of human civilization as to write a sonnet or construct a poem. I tell you this so that I have in you (although you be on the other side of the divide) a close confidante whom I tell everything I think. But please don't tell anyone. One must not speak about something that has not been accomplished. But this clear light that I see there, far away, toward which I walk with confidence and joy and from which no one can turn me aside, I am guided by it. I know that it is the same star that appeared to so many men, and that it signals the crossroad where all minds meet, where all scientists are great artists and artists are scientists. I see it. The road is long, but I will remain strong. I understand that I will be criticized, misunderstood, fought against, scorned. I know that it will be necessary to sacrifice many enjoyments and leisure, and that life cannot be spent making excuses. I know all that, and I walk forward *intently.*
>
> And if I fall before arriving at the finish, I will have fought well.

George and Mabel Sarton shared in this world of purpose and abstraction. Their life together was a scramble for resources without compromising their artistic and social integrity. But there is something else in George's manifesto. It exhibits the arrogance and naïveté that made him a disciplinary father without academic children, in his university setting and in his family. George directed only two doctoral dissertations; one of the authors succeeded him at Harvard, and one enjoyed a distinguished career in his native Turkey.

George's daughter May Sarton did not attend college or university, even though she ended up with 18 honorary doctorates.

Love and art figure explicitly in George Sarton's plans. Suffering from uncertainty and depression, George penned one of his most admired essays as a preface to volume 5 of *Isis*. Written at Intervale, New Hampshire, during the summer of 1922, it is titled Knowledge and Charity, and in the text George wants to show that history of science is about both head and heart, both works and the people who accomplish them. Acquiring knowledge is a moral duty, George emphasizes, and the people who do the most to advance knowledge are a small vanguard of humanity. These are the people best suited to guide us, not politicians and generals who do not know the world into which they are leading us. Conventional humanists, he names Matthew Arnold, equate scientific knowledge with crass materialism. George thinks that the problem concerns utility: If I study anything for the sake of utility, this may increase my usefulness and better my position; this will not enlighten me. Science certainly enables us to extract from nature for the benefit of all men, wealth untold and treasures beyond the wildest dreams of avarice. He affirms, it would be mean to cultivate science only because it pays to do so, but it would be incredibly foolish to believe that it can have no spiritual value because its material value is so immense. He warms to the main point: Science is the search of truth and, insofar as our quest has been successful, it is truth itself....the foundation of everything, the axis of our life, the substance of our reason, the key of our fate. The revealing of truth proceeds without reversal: Whenever a particle of truth was finally established, it was established forever; the advance might be slow but it was certain. The history of science is nothing but the history of this protracted struggle between credulity and research, of this long series of partial deceptions and progressive discoveries. Knowledge, obtained in this way, enlightens human kindness, it reduces the appalling danger of blind and misdirected generosity. In a phrase evoking Jesus, George offers that the noble sentiment love is the intermediary of enlightenment. The proof of this contention is in the obligation of truth seekers to give it, liberally, to all who may want it. Kindness, then, as Beethoven remarked, is the surest sign of nobility, and the visible sign of kindness is charity. George's long prolegomena leads to a focus on the human circumstances of scientific discovery including struggle, egoism, and perfidy. Revealing that side of the Human Comedy provides scientists with a proper sense of intellectual values. And in pursuit of that goal, historians should strive to be brief, identifying themselves with one great work or one single ideal. All these points relate the New Humanism, which will complete against the Old Humanism, that is to say, it announces the relevance of the history of science as a field of

scholarship. George concludes:

> The historian of science has in him the stuff to make a complete humanist, but he will fail altogether to be one, unless his knowledge be tempered by charity and seasoned with tolerance and humor, unless he be prepared to consider every scientific achievement almost in the same spirit as a work of art, unless he have trained himself to take the whole of life into account.(21)

Truly, *tout est dans tout*. George's logic breaks at a number of points. His philosopher colleague at Harvard Alfred Hoernlé, for example, criticizes George for holding in this article that truth is co-extensive with, and limited to, science and the use of scientific methods, a view that does not take account of the limitations of science.(22)

Art, apparent in Knowledge and Charity, runs like a red thread through George Sarton's life. His friend Emile Masson emphasizes that from his youth (the two corresponded beginning around 1905), George was captivated by Jan and Hubert van Eyck's triptych, The Adoration of the Mystic Lamb, displayed in the cathedral of St Baafs in Ghent, and he especially appreciated Jan van Eyck's Madonna from the Inn's Hall showing the Virgin reading a book, which he took as an allegory of science.(23) The promoter of a discipline of history of science saw art history as the reverse of his medal. Across the first three decades of the 20th century, he published on art and artists, and he considered founding a journal for the history of art to complement *Isis*.(24) Mabel the artist was the yin to his yang. The struggle of artists offered him secular saints, just in the way that the struggle of scientists did. He heard Feodor Chaliapin on 15 April 1923, and remarks in his diary that the singer worked as an apprentice to a shoemaker in the same street where Maxim Gorky was toiling in an underground baker's shop.

George Sarton selected his authorities for art carefully. He cites William De Morgan's Result of An Experiment (published anonymously in 1909) in his diary on 1 March 1923:

> It is the best thing on Earth that incessant struggle....Art is more important than you think. But it must be earnest, grim life-earnestness that has no tincture of gain in it or love of earth-fame, only the strength of one's arm, & the whole power of one's being is to be given to it; and to look neither to the right nor to the left, but go straight on doing the best that is in one.

The source of the quotation is revealing. William De Morgan and his artist wife Evelyn, inspired by the Pre-Raphaelites, undertook experiments to collect automatic writing, allegedly the communications of angels and spirits. George flirted with spiritism in his youth, and he comes back to it through

friendship with physicist Daniel F. Comstock and parapsychologist William McDougall at Harvard.(25) In middle age, George is still a youthful bohemian in spirit, spending more time and money than he has on *Isis*--his writer's canvas--and Mabel is tiring of it. Did they sense how much they resembled Puccini's Rodolfo and Mimi? They never comment on *La Bohème*, although Somerset Maugham's portrayal of artist Paul Gauguin moves them both deeply.

Building for the ages is a daunting prospect in academia, as in other walks of life. Taste and fashion evolve: The Clarendon physics laboratory at Oxford, for example, originated in monies dedicated for an equestrian academy. Sources of funding suffer the indignities of economic change: Family men hesitated to accept Isaac Newton's Lucasian chair at Cambridge, endowed in the seventeenth century by annual rents worth only , 100. But George Sarton did create the foundation for a grand structure. In a typewritten text of an article appearing in March 1917, composed after June 1916, George outlines an *Institute* dedicated to the History of Science and Civilization. It is likely that Mabel assisted him in writing it or, perhaps, in typing it.(26) George and his family were then in exile, living precariously in Cambridge, Massachusetts, where he lectured at Harvard University. In his text, George emphasizes that science is the very bedrock of our modern society, it is man's true universal language, and it is the strongest force that makes for the social unity of our civilization. Immanuel Kant proposed that the object of universal history was the growth of a universal community pursuing a common purpose. More than a century later, that purpose is seen as the creation and diffusion of beauty and knowledge. Science alone is universal and progressive. History of science has as a goal the genesis and the development of scientific facts and ideas. All the sciences had to be studied together, a point emphasized by Auguste Comte, who understood that the history of science is the logical basis of any philosophy of science and indeed of any philosophy. George desired the institute to be engaged primarily in research and only secondarily in the training of teachers. His model is the astronomical observatory, where each associate has a task according to a general plan and in proportion to his own abilities. This kind of institution is just the thing to raise the intellectual level of the nation, and it would make it easier to graft on the young and strong American tree all that was fine and great in the earlier Eastern and Western civilizations. If his plan succeeds, it would be the cradle of a New Humanism. George's notion of the material conditions of the institute includes a library, offices for the fellows, iconographical collections, and photographical facilities. He indicates two institutes as models for what he proposes: Karl Sudhoff's institute for the history of medicine in Leipzig, and the late Karl

Lamprecht's historical institute, also in Leipzig. Assets that could be acquired by the institute include George's own library (abandoned in Belgium), his friend Arnold Carl Klebs's library in Nyon, Switzerland, and David Eugene Smith's library in New York. The institute could be supported by a society, in the same manner as geographic or astronomic institutes. He gives as supporters a number of prominent American scientists and historians, and he provides nine historians of science and medicine who approve of the plan: Smith, Klebs, historian of biology William Albert Locy at Northwestern University, historian of Asian technology Berthold Laufer at the Field Museum of Natural History in Chicago, medievalist and historian of medicine James Joseph Walsh at Fordham University, William T. Sedgwick and Harry Walter Tyler of Massachusetts Institute of Technology, friend and patron Edward Clark Streeter, and medical bibliographer Fielding Hudson Garrison in Washington, D.C. Sarton included, we see here a minion for the discipline of history of science in the United States. Within the decade, a number of these players rallied to George's cause and founded the History of Science Society. The Dibner Institute at the Massachusetts Institute of Technology, created in 1992 from the estate of George's friend Bern Dibner, finally realized George's larger project.

Persistence wins George Sarton a research position with the Carnegie Institution of Washington. His stated project never realized is an exhaustive study of Leonardo da Vinci. A maiden publication on the topic appeared in *Scribner's* in 1919. George focuses on themes that relate him to Leonardo. He emphasizes that Leonardo was taken from his mother at an early age (George lost his mother as an infant), and that his father had four wives serially (George's father, chief engineer of the Belgian railways who died in 1909, never remarried but was not immune to female charm): A motherless, brotherless, lonely childhood, we cannot lay too much stress on this; it accounts for much (George, an only child, had few friends). Leonardo served many masters, some of whom failed to appreciate his genius (George, by this time in his life, had worked for half a dozen employers). He was a solitary man, who died before his time. Only those who have known suffering and anxiety can fully understand the drama and the beauty of this life (George worried continually about Mabel's health and about making ends meet). Then to Leonardo's observations of nature and his mechanical contrivances, including flying machines. He practiced inductive philosophy 150 years before Francis Bacon. His manuscripts provide a unique window into the creative genius who applied the spirit of craftsmanship and experiment to the question for truth, its sudden extension from the realm of beauty to the realm of science. Elaborating 5800 pages of Leonardo's manuscripts would be

George's task. He concludes by placing a message in Leonardo's mouth: To know is to love...My life was one long struggle with nature, to unravel her secrets and tame her wild forces to the purpose of man....A literary education is no education. All the classics of the past cannot make men....The study of nature is the substance of education, the rest is only the ornament. Study it with your brains and with your hands. Then George speaks: We must try to reconcile idealism and knowledge, science and art, truth and beauty....In the last analysis, that is what Leonardo tells us, and it is also the message of the New Humanism.(27) The New Humanism, George Sarton's shorthand for history of science, becomes the signature for an academic discipline by the middle of the century.

For a major figure among scholars, George Sarton was slow to hit his stride. As compensation, he corresponded with ferocious intensity, a passion shared by his wife Mabel. The young couple held their early exchanges so dear that, before they left Belgium for the Netherlands as refugees at the beginning of the First World War, they buried their correspondence in the garden. Friends subsequently deposited the letters in a vault at the Banque de Flandres in Ghent.(28) In 1920 George brought the letters to Cambridge, Massachusetts, without opening them. To-day I opened one of the packages, hers but could not bear to analyze the contents, George writes on 5 May 1950, following Mabel's death. I lack the courage to destroy them as they perhaps deserve to be destroyed, he continues, and he prefers to leave them to the scrutiny of indifferent and objective hands.

Mabel and George Sarton were indeed devoted to the epistolary art. Mabel's mother observes to Mabel's friend Céline Dangotte around 1901: I do not like writing letters. (Where does Mabel get her love for it from I wonder?!!)(29) They would plan their day or week to be able to write to each other at length. On occasion, they would write twice or even three times in a day, the letter carrier becoming almost a private courier. They wrote frequently to each other when they were separated by long distances, and also, before they were married, when they both lived in Ghent. (Their residences in the core of the medieval part of Ghent were a ten-minute walk apart.) In the years before the First World War, mail traveled efficiently across Western Europe. A letter mailed by George in Ghent could arrive later the same day with Mabel in a small Swiss town. Urban delivery could take a matter of only hours. The system allowed George and Mabel to elaborate thoughts with precision and conduct a dialogue when ideas were still fresh in mind. Mabel's and George's lodgings in Ghent and in America had a telephone.(30) But instead of speaking, each preferred to set down intimate thoughts by hand. When they were apart, letters continued a conversation of theirs, whether

during the day or weeks previously. On occasion, letters over the course of many days were posted together. George sometimes cried for letters from Mabel, if only a few lines on a postcard; Mabel felt a mixture of fear and excitement when she opened a letter of George's. A long letter from Mabel to George on 26 February 1925 begins: I must come & talk to you. Letters are dreadful things are they not? & yet so precious! (Even when they upset me of course I would rather be upset than not have any letter that week!)

The Sartons' exchanges are unusually frank and forthright. On 14 July 1923 in Ipswich, England, Mabel is happy to receive George's and May's short letters, even though, in French, they told me little of importance. In their correspondence, they often bare their deepest concerns. This feature is especially interesting because the language of their early letters is French, by then a highly inflected literary vehicle. The straightforward prose results in part because they set down emotions without the advantage of sharing a mother tongue, although it is also an expression of their character. They kept secrets, but dishonesty was foreign to their spirit, and they both sought, above all, essential qualities in life. For example, on 10 May 1915 Mabel writes to George. Mabel is in England, convalescing from measles; George is in Washington, perilously beginning his academic career in the United States. Mabel returns to the matter of her illegitimate birth (her parents married a short time later). She wonders if George spoke about it to a colleague, with whom he worked for a number of months in the War Office in London:

> Tell me, did you perhaps tell him the circumstances of my birth? All that wretched thing, it has been haunting me. Can you understand how grieved I am that these facts, against which *I can do nothing*, can be an instrument against *you*? I did not imagine they could be of such importance, even break your career. That is a terrible thought. I loathe having *something to hide*, something one is *afraid* should be known! I feel almost that if I were *alone* I would go to the other extreme & sift my friends & acquaintances by telling them the truth as quietly as possible.

She needs to obtain travel documents from the Belgian Embassy, and when she goes there she will do her best to keep the matter secret. One thing I have decided: When she is big enough, May shall be told. I myself will tell her.

The first part of the correspondence is almost entirely in French, until in 1910 George began to write in English. George records, in his manuscript biography of Mabel, that early in their relationship we always used *my* language, which she knew, not *hers*, which I did not. He continues that in 1909 he took a Berlitz course in English, but the instructor advised him: You will never be able to speak English properly. (His diary indicates English

lessons from September 1907 into January 1908.) George writes to Mabel in 1910 (perhaps on 16 May), to thank Mabel for her beautiful book bindings: Never fear to speak to me in English, for I adore to hear it spoken. The few words that you have spoken to me have given me pleasure. Yet George indicates in his unpublished biography of Mabel that he could not read English books aloud, in the early years of his marriage: I could not read well enough nor could I understand what was read to me. George's American correspondent David Eugene Smith compliments him on his English prose in 1912--It is almost without a flaw although Mabel is likely responsible for the result.(31) As late as 26 February 1925, Mabel wants to make sure that George understands her recent letters, where she identifies in him a frightening vagueness concerning, not only future obligations but *existing ones*. Mabel thought you were worried very much & *afraid to tell me the whole truth*. She wonders if the problem is George's style: In spite of wonderful ease you do still use English expression queerly. His delivery, forged in positivism and Belgian socialism and tempered in reaction to American pragmatism, radiated authority and abstraction, making George a difficult man to know.

Mabel and George Sarton admired writers formed in the nineteenth century (Carlyle, Ruskin, Maeterlinck, Romain Rolland, Fromentin, Tolstoy) and they read omnivorously, but their own writing is for the most part the uninflected, workaday prose favored among practical people early in the twentieth century.(32) Style among younger academic writers declined dramatically at this time. One is tempted to associate the decline with the great democratization of universities, which saw enrollment growing in leaps and bounds; increasing teaching burdens on the shoulders of younger scholars; and a desperate contest for visibility in the specialist, periodical literature, required for landing a university chair. The plain-speaking that echoes in their correspondence with each other radiates earnestness and authenticity; it is when they try for metaphor or allusion that the words fall flat. George and more often Mabel are confused or upset by figures of speech sent by their correspondent. Each knows that something is not right when the other dwells too long on abstract matters.

The intense passion of family life is clearly revealed in correspondence. George asserted from the beginning that his work would come before wife and children. He writes to a close friend, Raymond Limbosch, on 11 July 1907 that his life has quite gone in one direction, that he has a ministry [apostolat] to fulfill. Furthermore, everything is subordinated to my purpose: my life, that of my wife, of my children, if I ever have any, that of my friends. Whoever hesitates in the face of the sacrifice is not worthy of undertaking

great things. God has not chosen him.(33)

The religious streak apparent here marked George for his entire life, and he was especially drawn to religious authors. He confides to his diary on 21 April 1904 that Francis Jammes will be his spiritual guide. To Mabel he writes an enthusiastic postcard on First March 1911: I like Francis Jammes more than any other author in our time, & I was often shocked & saddened to feel that he was not entirely understood. Jammes, the French poet and novelist, was by then the apostle of *naturisme,* a reaction against Symbolism where the focus is on common, everyday occurrences. Jammes converted to Roman Catholicism in 1905 under the influence of Paul Claudel, and in 1911 the first volume of his novel about a Catholic peasant family, *Les Géorgiques chrétiennes,* appeared. In a letter to Mabel of 1 November 1906, George writes that for the past two years the only author he reads regularly is Ernest Hello, whose work *L'Homme* (Paris, 1872), into a seventh edition by 1905, he admires. The book is a collection of essays divided into the themes of life, science, and art from the perspective of Catholic theology. Hello, in particular, rejects Descartes's separation of spirit and matter. It may be imagined that George, a socialist attracted to the religious life, was particularly struck by Hello's emphasis on the synthetic union of nature and mind, and also, perhaps, by Hello's lives of the saints. The sense of unity guided George into middle life. He emphasizes to Mabel on 9 November 1924 that he is increasingly persuaded of the unity of the world & my own utter insignificance in it. Furthermore,

> I deeply respect the religions of other people, however absurd its form, if it be genuine. I do not simply respect their religion, but I love it through them, because of them. It is *their* form of the ideal beauty & justice & truth; however different in appearance, it is not essentially different. It tends towards the same direction.

For George Sarton, the Bible instructs that the difference between the ignorant & the learned, the fool and the wise is not as wide as it may seem. If their hearts are right, they are almost entirely right, I am sure. In the course of his life the sentiment attracts him to a wide variety of universalist philosophies, from Transcendentalism and Theosophy to Buddhism and Christian Science.

Mabel Sarton did not share her husband's religiosity. On 23 November 1924, writing from Europe to George in Cambridge, she comments on lines of his about advancing along a road toward his goal:

> In my thoughts I saw you so clearly trudging along & I saw myself beside you, sometimes having to run to keep up, & sometimes walking hands in yours a step in front of you, helping you along. I followed us for miles & miles, with me playing back & forth like a little dog, & I felt

> so deeply proud & happy, because you *really needed* me, to help you along towards your goal. If I took a bye-path, you kept looking for me & you walked near slowly. It sounds quite commonplace written down, but it is something I cannot forget, & your letter gave it to me. You have to be strong for your work, & for us, but *you need us* too, even for your work.

She knows that George loves them, her and May, but only now does she know what she hoped, that he needs them. I feel quietly sure you need us, not just to round out your life, a sort of ornament to it, beautiful but outside it, no, as a necessary part. That is like a quiet, sure hand that comforts the frightened part of me. Mabel turns to George's thoughts about the unity of the world: I *cannot* see the unity. I *cannot* accept the horrors & unspeakable anguish which puzzled, racked humanity (& animals too) goes through. I *don't* understand & cannot say I am [illegible] to believe there is an explanation. She cannot be happy because of the suffering of others.

> Nature? Yes, outwardly so alluring, so beautiful, & always beneath the beauty, pitiless cruelty, pain, decay, death. The beauty appears to me, & the happiness, an inexplicable accident, a surface thing, a deception which makes the reality worse & more hideous, like the flower a butcher places on the bleeding carcass. There is only one thing I adore & know to be beautiful & true: love, unselfish love, the instinct to protect *& to give.*

Religious explanations are only creations of the human mind. The whole difference is that you accept & I cannot. You believe there is a pattern, an answer, a unity. I see darkness, with one simple shining frail thread. George

> will say: after death & decay, absorption & resurrection. And I shall say, the pain & death & decay will *go on* repeating themselves. What is the good of beginning over again if for most creatures the sum of pain & fear is so much greater than the happiness? And it is not *our own* that is the worst. The moment we love, we suffer infinitely more for the beloved than ever for ourselves, & most often we are quite helpless.

Here, in starkest terms, is how a scholarly discipline hung on a marriage, and here is also a difference in spirit between wife and husband.

George's sympathy for people of faith suggests that he is familiar with sacrifices of children to garner divine favor in Antiquity. Among the sacrifices he asked his family to endure is placing his daughter May on God's altar. On 11 June 1915 Mabel writes from Manchester, England, to George, who is teaching at the University of Illinois. She is beside herself with George's thought that May, then 3 years old, be given to Mabel's relation Katherine Lady Barker. I have been startled & rather upset by a letter from

Katherine enclosing yours, with the suggestion of her taking May for an unlimited time. Mabel reflects: Ah Beloved, it has been such a revelation to me, that letter of yours & if it has not at all succeeded in its set purpose, it will yet have brought much good to us all three. Mabel is seriously ill with measles and depression. She appreciates George's desire to care for her, but it is absolutely impossible for me to give up May to *any-one*, however much I like & trust them, for more than a few weeks or months. I hope it will never be 'months' again. Mabel is grateful that George wrote the letter, except for one thing: I have a hurt, sad feeling because you thought I would consent to give up our little daughter for so long, perhaps years. May-be it is my own fault though.

Two years later Mabel was pregnant. She waited to give birth in Cambridge, Massachusetts, while George taught summer school at Columbia University. On 28 July 1917 George writes a somber letter:

> Sweet & good wifie,
>
> I am extremely unhappy because I am anxious about you & the little one, & also and not less because I am not at peace with myself. I cannot be happy when I do not work, and I feel that I do not work enough. It is true I am delivering some good, some very good lectures especially in my course in the history of mathematics. But I do not do any serious work outside of that, & I have never felt more lazy & dissipated. I have been reading, I do not say studying a lot of Arabic & Chinese literature, but without enthusiasm & my soul is slumbering. It is true that I do not read a line without a purpose, a single purpose, & that these desultory readings contain much fresh material for my own thinking, but my soul is slumbering, and I am cold.
>
> I am also unhappy because I have just realized too late that I should have left yesterday night to visit you in Cambridge. I might have been there in time to welcome our little son & cheer you up. But maybe you will not be delivered until your own birthday.
>
> I do not call you beloved, although you are the beloved; neither dare I kiss you because I feel in disgrace.
>
> Your husband
> George

Mabel replies on 29 July:

> I am a little tired of waiting & of the heat & of our separation, that is all. Don't pay any attention if I seem depressed. There is *no* real reason to be so. Quite the contrary. So let your heart take courage.
>
> But oh! How lovely it would have been if you had come. Still I would rather it was at *the* time & not before! & though I long for it dreadfully

I do not feel we ought to give way to our longing because of the expense. Do you know it helps me so just to know *you wanted to come*!

Mabel tries to cheer him up: Just put your hand in mine & feel that I am not only the Beloved, but the Comrade too, so near, so near to you. Don't you feel that? I feel it so for you! You are sometimes a hero to me, but you are sometimes just a dear, faulty human being, to whom I dare confess my weaknesses & be helped & comforted, as no 'always-hero' could do! A son was born and died after several days of a congenital bowel obstruction. George may or may not have seen his son alive.

Just as the Sartons represent modern parents, for whom children are a blessing as well as a burden, so they were no strangers to conventions of their time. George, in his English publications, refers to mankind and men of letters, and in French to l'Homme. George is conventional in viewing women as objects of desire, and early bugbears, in popular publications, are snobbish women who have a bit of university-level education.(34) Readers interested in sexing prose, as one might sex a chick or kitten, could find grist here for their mill, notwithstanding the fact that some 10% of George's professional correspondents are women, a large fraction for the time. I prefer to think that a more credible picture of George's and Mabel's sexuality, as well as their views on the gendering of knowledge and art, emerges from their intimate notes and correspondence. In his early publications in English, where women snobs appear, George wrote for money, and he certainly knew what would sell. There is not the slightest suggestion that George ever resented Mabel's artistic success as a designer or, later, his daughter May's success as a woman of letters. All evidence supports the contrary assertion.

Race is a word appearing often in their writings and in their correspondence, but both George and Mabel were explicit about their disgust with racism. Mabel Sarton, in Washington, writes to George, then lecturing in Worcester, Massachusetts, on 14 April 1916 about Mathilde Lafontaine, wife of Nobel peace-laureate Henri-Marie Lafontaine. She is the very antithesis of Henri-Marie, & she must surely do him a good deal of harm by her tactlessness & fanatical ideas. In French: She is a *hateful,* nasty, *stupid* woman. And the worst of it: Then she spoke about Niggers, finally a detestable mind. Mabel finds Mathilde Lafontaine just as the worst Germans are, with their stupid and criminal hatred.

The condemnation of racism derives from the Sartons' ideals about human rights and pacifism. Fellow Belgian exiles Henri-Marie Lafontaine and George Sarton made common cause, even though their views of pacifism differed. George inclined to be internationalist to a fault, while Lafontaine was more attuned to the compromises of practical politics. Lafontaine, for

example, did not share George's view that Germany and Austria were victims of militarism, and he could not imagine a Paneuropean political union.(35) George honored his principles more resolutely than Lafontaine did. When he declined to lecture to the Navy League because it was too jingoistic, even though he desperately needs the honorarium, George Sarton records by way of justification: I am resolutely and at base a pacifist. But I believe that one of the conditions of peace is a solid national defense.(36)

Sigmund Freud cast a long shadow across the first part of the twentieth century, and especially so when the intimacy of man and woman is in question. George Sarton observed psychoanalysis in the second number of his periodical, *Isis,* in 1913. In 1920, reviewing Freud's study of Leonardo da Vinci, George delivers a stunning rebuke:

> Those who wish to know to what degree of absurdity Freudian psychoanalysis can be carried and that by the Master himself! have only to read this book. These complicated and extravagant theories based upon the scantiest and most uncertain facts are a credit to Freud's ingeniousness rather than to his critical spirit. It might be time to make a psycho-pathological study of Freud himself!(37)

Dreams, childhood deprivation, and sexuality all have a place in the marriage, but psychoanalysis and psychological theory would be too heavy a burden to place on the shoulders of the Sartons. The thought of psychiatric help never occurred to them, even though they like their daughter who did consult a psychiatrist, were surely candidates for it.

May Sarton, daughter of Mabel and George, is present through much of the story of her parents' life, both as a commentator and as a participant. She is widely known today as a feminist poet and writer, in part because she is one of the earliest women in the United States to acknowledge in public her own lesbian, sexual preference. In fact there is very little sex in her writings, which are almost Platonic in their search for purity and essence; May Sarton shares this stylistic orientation with Mabel and George. A reader may seek the origin of May's sexuality in the account of her parents. Is it nature or nurture? Both May and her authorized biographer have emphasized her unusual upbringing--lacking a permanent home, ignored by a possibly neurotic mother and a self-confessed, emotionally-arrested father.(38) But Mabel and George are deep and sympathetic figures, and they raised May creditably and honorably. Whatever material shortcomings there were in May's youth, she was guided by two passionate intellectuals to appreciate the life of the mind, something intellectual parents strive for today. Evidence is available for Mabel's hormonal imbalance in the years before and after May's birth; to correct the imbalance, she was one of the first women to receive hormonal

therapy.(39) It is an open question if this circumstance is the origin of May's constitution.

Sex occupies a relatively large place in Mabel's and George's early correspondence, as it does in the life of many young people. Documents provide an unusually complete picture of their sexual life, which they observe without prudery. In 1910, for example, they correspond intensely about the writings of Auguste Forel, the Swiss psychiatrist, entomologist, and sexologist. Mabel Sarton has read almost half of Forel's study of sex, she writes on the 17 June 1910: It is a beautiful book.(40) Her views about Forel evolve. She continues the next day:

> Forel's book brings up many things. I know very well that the sexual question was very complex and difficult to resolve, but I understand it ten times better now. If the book made me calmer, it also raised a problem so agonizing that I must bring it up. I find myself calm because now I *know*. However, it shows that a man has sexual needs difficult to please, which must be satisfied before the age when he may normally marry. So he [Forel] easily admits that houses of prostitution are a necessity (in one form or another), and so there will always be women dedicated to this role? And he shows that the class of women for whom this is natural is very, very small (they are aberrant people). So these women will be eternally victims of the situation, *inevitably*. This revolts me and saddens me. I do not see a way out. He gives no hope. *The two physical natures of man and woman are then not in harmony* on the level of humanity.
>
> I fear that what I say to you will seem rather futile, with your way of reasoning. Yet I must think about it more, before seeing in a clear way my own conclusions. Also I must finish the book. I think I will read everything. I am beyond the middle. But I want to reread before continuing because I have not at all assimilated enough.

Finishing Forel on 19 June, Mabel writes to George that she is left with an enormous weight, thinking about all the misery and degradation that most of the book evokes. She can't accept his conclusion that women should marry between 17 and 19 so that men's sexual needs may be satisfied normally. Even if a woman is completely formed from the sexual standpoint at that age,

> from the moral and mental point of view, *she certainly is not*, in my view. I know no young girl of that age who is capable of choosing the man who will really complete her life, and above all I know none of that age capable of *raising children well.* I can imagine no future where they will be so. If it happens, it will be at the price of an *attenuated* childhood and adolescence, and I give great importance, on the contrary,

> to *a real adolescence*, long enough for a character to form joyfully, freely, slowly. He supposes perhaps that men carefully use *for a number of years* the contraceptive devices that he describes? I don't see it at all. The men who are capable of that will always be exceptional, I am sure of it. And then he often easily recognizes how difficult it would be to eliminate, even to improve the conditions of prostitution. It seems to me that in fact the conditions will change and improve, but the essential fact will remain. This is a sad, sad, sad thing.

Mabel Sarton's views seem close to those of Iwan Bloch, whose 1912 treatise on prostitution received a review by George in the first volume of *Isis*.(41) It was something George knew first-hand. A compulsive note-taker, he regularly recorded coitus by making a Maltese cross in his agenda. The evidence, which seems conclusive, indicates that at several points in his life, he was unfaithful to Mabel. George's attraction to Forel extends to personal hygiene. According to his diary, George becomes a strict vegetarian on 16 February 1908 and also gives up alcohol, joining the Ordre international des Bons Templiers, a temperance organization promoted by Forel; his allegiance to both regimes is inconsistent.(42)

Concluding his study of historian Thomas Carlyle and Jane Baillie Welsh, Osbert Burdett notes: Records of any marriage are as rare as they are precious. Burdett emphasizes:

> The story of the Carlyles is an authentic history substantially repeated in a thousand homes. It holds, interests, and at times exasperates us, as living problems do. The love, and the difficulties, the misunderstandings and the unity, the friction on the surface and the devotion at the core, are the mirror of the confusion of daily life.(43)

But the remarkable, epistolary exchanges of the Carlyles, for whom some 10,000 letters exist, are silent about marital sex, leaving us to infer intimate matters only from the gossip of acquaintances.(44) A recent biographer emphasizes: No amount of speculation, or reviewing the speculations of others, can take us further into the mystery at the heart of this, as of any other, marriage.(45) The Sartons mirror the Carlyles in a number of ways: Their long engagement and turbulent marriage, their sense of ease with the cultures of Western Europe, the self-imposed isolation of the writer-husband and the resentment of the sensitive, invalid wife, and their compulsion to write. Still, the paper trace left by the Woolfs, notably Leonard, is perhaps closer to what we have from the Sartons, especially George. Lord Annan summarizes:

> Leonard Woolf, counting the dates of Virginia's periods because he had detected a correlation between delay in menstruation and her bursts of manic depression, became transformed from the devoted husband into

> an anal monster whose so-called concern for her health was on a par with his habit of keeping meticulous accounts, logging the number of miles he drove, recording the date he had his hair cut, the number of bushels of apples yielded by each tree in his orchard, the events of every day for fifty years and their exact expenditure and earnings.(46)

George Sarton, four years Leonard Woolf's junior, also married a woman with artistic temperament older than he, a woman who also wrestled with depression. Mabel Sarton, like Virginia Woolf, was a creator sustained by a husband who kept detailed records of his moral and material progress.

The Sartons were conscious from their young adulthood about the significance of letters for future times. They avidly read biographies and autobiographies as a part of their program for self-edification; on occasion, biographies motivate their actions. George writes in his diary on First August 1954: I love to read biographies of great men but it is only the beginning that interests me, the years of struggle and more often than not, of misery. When success comes in I am ready to leave. Mabel and George Sarton did not write for posterity, however. They saw their letters as a record, for themselves, of their spiritual and emotional progress. They often reread and commented on past correspondence.

Mabel Sarton expressed the notion clearly when she visited the home of the Carlyles in Chelsea. She writes to George on 23 June 1910 that her umbrella was stolen (later she comments that she left it in Chelsea), but she does not mind because she was so impressed by the house. She read some of the love letters between Thomas Carlyle and his wife, Jane Welsh. In French in second-person familiar: In general it displeases me very much to see such letters published. This time, I think that it was necessary to justify them both. I can't define why just now, but I felt yesterday intensely that you resemble Carlyle. George indeed admired Carlyle, by virtue of Carlyle's correspondence with Welsh. He writes in his diary on 31 August 1910 about himself and Mabel: I can say of us what Carlyle said one day of Jane Welsh: Has not a kind Providence created us for one another? Have we not found each other? And might not both of us go round the Planet seeking vainly for a heart we could love so well?' It is a quotation he sends to Mabel on 18 February 1911, after parting from her in France. Carlyle was the historian who fired the mind of both the young and the old George Sarton. On 31 August 1905 he notes in his agenda the translation of Carlyle's writings by Emile Masson, with whom he became friends. To Andries MacLeod, son of the Flemish nationalist and biologist Julius MacLeod, George writes on 13 January 1947: Your life in Vintjärn [Sweden] makes me think of Carlyle's in Craigenputtoch, where the silence was so deep that his wife, Jane, could hear

the sheep graze.(47) Carlyle, whom George Sarton finds a kindred spirit, was foreign to many of George's contemporaries, notably Virginia Woolf, who visited the Chelsea house on 24 February 1909 in preparation for reviewing an edition of the love letters for the *Times Literary Supplement.* She writes about the Carlyle marriage: It taxes our powers to the utmost to understand; the more we see the less we can label, and both praise and blame become strangely irrelevant. Woolf concludes after her visit: Did one always feel a coldness between them? The only connection the flash of the intellect. I imagine so.(48)

The action of a life is not chronicled entirely in contemplative correspondence. In times of crisis, the courage or the will to write letters may fail. Even among people who may seem born to the pen, intense emotions can preclude discursive prose. When people live together, furthermore, they do not generally write to each other about daily occurrences. Supplementing the correspondence are George's diaries and appointment agendas. George kept these accounts for his entire adult life, and he was meticulous to a fault. Mabel also kept a diary. On occasion they showed their diaries to each other. George sometimes had an acquaintance write an address in his agenda. It is striking that George's diaries from 1907-1911 and 1914 are missing, as are his agendas from the early years of his marriage in Belgium. From early 1917 to June 1919 George kept his diary on cards, his memindex; he resumed a conventional diary at about the time he returned with his family to Belgium. The cards are unavailable, and Mabel's diary has not been located. George's missing diaries cover turbulent times, but in view of the material he preserved there is no reason to suspect that he destroyed them.

Because Mabel and George Sarton were much concerned with recording their moral progress, they were only moderately successful at isolating their professional life from their marriage. Mabel kept house, painted, and designed clothes and furniture. George published, lectured, and wrote countless professional letters. George referred to professional correspondence as a *besogne*, a task, and he tried to handle it as quickly as possible. In professional matters, he ironically preferred sparkling conversation to letter writing. His friends in Cambridge came from a wide variety of disciplines, as they did throughout his life. George's correspondence relating to his periodical, *Isis*, and his scholarly writings provide information about his personal life, as does Mabel's correspondence with Céline Dangotte, her adoptive Belgian sister, in whose enterprise in *art décoratif* Mabel worked as a designer through the 1920s.(49)

Mabel Sarton in fact established herself as a leading designer well before George obtained a comparable place in his chosen profession.

Photographs of a number of Mabel's works appear in the 14 January 1911 number of the British avant-garde periodical *Studio*, accompanying an article written by the Belgian Symbolist painter Ferdinand Khnopff about the Universal Exhibition at Brussels in 1910. For the exhibition, Mabel had collaborated in the interior design of an entire cottage constructed by architect Oscar van de Voorde. In his article, Khnopff deplores the fact that the modern school of Belgian art was unrepresented at the fair, especially because the German exhibitors in art were explicit about their debt to Belgian colleagues. Khnopff observes that Van de Voorde follows Gustave Serrurier-Bovy's notions about simplification in art (which stemmed from the ideas of John Ruskin, William Morris and Eugène-Emmanuel Viollet-le-Duc). The architect was fortunate in obtaining the co-operation of Mme Dangotte, who chose and arranged artistically the various useful and ornamental articles; of Mlles Mabel Elwes and Méta Budry, who designed and executed the mural decorations and embroideries; and of M. Acke, who made the furniture. The references are to Mabel's adoptive mother and to her close friend, Méta Budry. Then follow images of five of Mabel's embroideries, produced both by machine and by hand. The motifs are flowers and a pair of peacocks.(50) The exhibit was indeed a triumph, as Mabel's adoptive father Léopold Dangotte observes; many people commented favorably on Mabel's work.(51) The exhibit and especially Khnopff's review mark Mabel's arrival as an artist, at a time when George was still a largely self-published student.

Not only was Mabel a pioneering artist, but she was also George's coauthor. Late in 1914 the Sartons were refugees in England. George, working as a military censor, wrote an article about Belgium for Paul Carus's periodical *Open Court*, and he asked Mabel to translate it into English for him.(52) It is likely that Mabel added ideas and substantive changes, for in a letter to Mabel of 22 May 1915, George calls it our article; certainly the text expresses the Sartons' common political credo. The article, The Future of Belgium, opens the May 1915 issue of the *Open Court*, an issue devoted to Belgium; the frontispiece is Peter Paul Rubens's Assumption of the Virgin. George is listed as the single author of the article. George begins by observing that one-eight of the population of Belgium is in exile; the people who remain are subject to deprivation and destruction. The cause is Germany's violation of Belgian neutrality. He does not want to discuss German atrocities. Rather, he emphasizes the broad social and economic reasons for the war, a whole world of realities, arguments, sentiments, above all of instincts, where the worst is mingled with the best; a great deal of unconscious ignorance and of kindness worked upon by a few selfish and criminal intellects; rare ideals and a mass of human mire. George is sure that Belgium will emerge from the war

wiser and showered in glory, while Germany will be dishonored for its treachery. He observes the tension resulting from 110,000 Belgian refugees in England, whose temperament does not fit well with English temperament. George concludes with a plea for maintaining Belgian integrity and independence after the war. Small countries, well fortified and well armed, interposed between bigger ones, *états tampons* as they have been called, appear to me the surest factors in the European equilibrium.(53) Defensive fortresses are the key. I believe personally that for long centuries to come it will be the peoples' duty to protect themselves by this means as it is the duty of individuals to put locks on their doors. The article repeated the contentions made by George and Mabel in an unpublished letter to Hamilton Holt's *Independent* of 1914 (signed by both of them), where they insisted that defensive armament does not contradict pacifism.(54) In their letter, the Sartons asked for reparations from the aggressors only for the purpose of an international foundation; in the *Open Court* article, George was in favor of heavy reparations from Germany after the war, both to Belgium and to an international fund.

In the publication of 1915 George recalls the plans for a world city designed by Hendrik Christian Andersen, aided by the architect Ernest Hébrard and a phalanx of collaborators. In October 1914, Andersen published a summary of his plans in the *Independent*, the periodical that received George and Mabel's peace plan in September 1914.(55) George, an omnivorous reader, may well have seen the summary, which would have recalled to him the third number of *Isis*, dated 6 November 1913, where he reviewed Andersen's plans. He said then: Three centuries ago he would have been placed on the block; a century ago, he would have been confined to an asylum; but today, an intellectual élite from all corners of the world gather around him to express gratitude and sympathy. Andersen's undertaking promotes internationalism. If the world center never arises out of bricks and mortar, will not at least the City of God, where original thinkers from all countries and all times find refuge, become more solid and real?(56) In 1915, George is convinced that the world city should be erected in Belgium, in the country sanctified by glorious wounds, and I believe that none of the other nations would protest. He is confident that Belgium will emerge healthier and inspired with higher ideals. He urges America to organize a commission to investigate war crimes.(57) Andersen concurs.(58)

George hoped that an institute for the history of science could be grafted on Andersen's world city in Brussels. In modern and postmodern times, people devoting themselves to ideas face the crucial problem of patronage. It might be thought that everything turns on practicality, for in the

nineteenth-century incarnation of Francis Bacon's New Atlantis, knowledge will cure illness and bring about a life of ease. But the nineteenth century also saw the rise of great museums, libraries, and humanistic institutions, along with eminently useless scientific institutions like astronomical observatories and vertebrate-paleontological collections. Morally uplifting endeavor is indeed prized by captains of industry and merchant princes, as George knew from his years in Ghent. With his move to America, George was struck by the pragmatism of his new environment. He sensed that it is insufficient to contend that history of science makes for better scientists, and he tried to hang his plea for history of science on whichever hook presented itself. In The Future of Belgium, the hook is American shock at the rape of Belgium. Later in the war, in an éloge of fellow Belgian exile Emile Waxweiler, the hook is a new sociology.(59) Neither hook held firm. George's support, from the moment he stepped on American shores, derived from patrons who were interested in abstract ideas. The greatest supporters of arts and sciences wish to go beyond mere utility.

The available letters are clear that Mabel and George bare their soul to each other, but they do not reveal everything. In 1928 Mabel writes to the artist Lucy May Stanton, whom she regards as her spiritual American sister, about her partnership with two women in Washington, a company known as Belgart:

> I have literally to ship & spur myself on from day to day & even then am dismayed & frightened to see that I cannot make ends meet, of strength, or money. I ought to find some other way of earning (& have tried in vain) because Washington will never pay me I fear more than a few drops in the bucket. They can't, they don't make money. Twelve year's designing, giving of my best, & here I am where I started, from the financial point of view & I feel too old & too worn out to find a new outlet. I confess I am horribly depressed & have been since June.
>
> *I don't want George* to know too much. It would only upset him & he can't help. I have told him a little because it is not quite fair to him he should not know at all. He is a *dear*, you know, & as blind & full of the conviction that he is the traditional bulwark between me & worries, as any other husband!(60)

George is also very close to, possibly intimate with, Stanton.(61)

George is remembered, by those who knew him, as a difficult, distant man. He spent his life scrambling for the leisure and the resources to undertake original scholarship of a synthetic nature. He was exploited by his employers: Harvard kept him as a poorly-paid lecturer for many years, and the Carnegie Institution of Washington, the source of most of his income, decided

not to continue its investment in history of science when he retired. His close friends twice brought in a younger historian to supplant him at Harvard.(62) He persevered. From the time of his youth he tended to be curt in personal relations. In old age, he became curmudgeonly. In her early adulthood, Mabel experienced more than a decade of ill-health and frequent depression, but she won nearly everyone whom she encountered by her warmth and generosity. Mabel was immensely proud of George, and George continually credited Mabel with having licked him into shape, making him less of an *ours mal léché.*

The marriage has been analyzed by May Sarton, daughter of Mabel and George. May expressed strong feelings about George's single-minded devotion to his scholarly labor and Mabel's self-effacing support of it. (George was amused at May's earliest writings about his table-talk, appearing in the *New Yorker*, and he corrected them silently.(63) May is clear about deeper levels in the marriage, which records mutual love and devotion in the face of may kinds of adversity. It is also a record of the perils and rewards of academic life in the first part of the twentieth century, when women demanded to be treated as the intellectual equal of men and when academics sought support for their projects from universities. Tensions evident in the marriage later became structural features of family life. The reversals of poverty, war, and perfidy, of hopes unrealized and small courtesies unremembered, did not dim their common credo, established in the years before they married. Love, beauty, self-improvement, and human betterment are consistent themes in their life together.

Judgment is also a theme in the marriage. Mabel and George strove not to judge each other, believing that love transcends critical appraisal; they sought to be generous in dealing with other people. When, on 3 September 1919, Mabel closed up their home in Wondelgem and packed away their Belgian silver and jewelry, she found time to look through their correspondence:

> I also put all our letters down at the bottom of the trunk. George, I am so happy those letters were not at the mercy of the Germans. I re-read a few of yours of *1908.* They are such dear letters. I wonder do you realize what progress you have made since then on unselfishness & real tenderness & generosity not only to me but to every-one? I don't think I realized it myself. Not that you were not already trying hard to be all that, but you were still extremely passionate & intolerant. Now you are much more deeply, truly, tolerant than I am.

Generosity is not frequently ascribed to George in the authorized biography of their daughter, nor in testimonials and remembrances. Yet it would be a

mistake, a century later, to look at the Sartons with a disapproving eye. They wrestled honestly with large issues. They succeeded, in the face of daunting obstacles, in raising one of America's most popular women of letters and in establishing a significant academic discipline. Their struggles, no less than their achievements, reveal the compromises that are endemic to intellectual and artistic life today. Their lives help define a great moment in civilization.

George and Mabel Sarton's sensibilities crystallized before the First World War. Among these sensibilities are their notions of art and literature, science and scholarship. The Sartons were certainly aware of radical breaks with the past during their lifetime: quantum physics, relativity, and abstract art. George, in June 1914, reviews the transformations in physics over the preceding decade that have entirely modified the horizons of science: the revival of atomic theories and the notion of discontinuity.(64) George was interested in the new art and the new science, but he kept a distance from them. For example, on 9 February 1948 George writes in his diary about a very instructive anecdote related to him by his mathematician friend at Harvard, Philippe Le Corbeiller. Paul Valéry, whom George admired,

> met Einstein at a party given in Paris in the latter's honor. He asked him whether he carried a little book to note down ideas that occurred to him. As Einstein said no, he began to explain the great convenience of doing so; he himself always carried such a book in which he had occasion to write many ideas every day, which might have been lost otherwise.
>
> Einstein replied smilingly: You know, I have so few ideas.

Instructive also about George, the compulsive note-taker who knew Einstein personally.(65) In 1908 George saw several paintings of Pablo Picasso's, a young Spanish painter still unknown who has an extremely original vision of life, but some of his canvasses are ghastly .(66) Neither George nor Mabel was much impressed with non-representational art, and George expressed his views in publications on art history. In a letter to philosopher Horace Meyer Kallen, George emphasizes: Our modern artists are rotten with irrelevant ideas. They want to know everything except their own craft, and the result is an awful mess.(67)

War and revolution are omnipresent in the Sarton correspondence, but there is relatively little about political elections. One senses that George and Mabel devoted their effort to works of inspiration, and above all to understanding each other. They sought balance and harmony, and they tried to avoid dissonance and iconoclasm. Late in life they each suspected that the world might not be governed by the ideals of their youth. Those ideals reflect the values of the first half of the twentieth century, just as pessimism,

relativity, and materialism dominate the second half. The Sartons' notion of truth, justice, and progress animates the United Nations and the Nobel institutes, assemblies that, despite the odds, continue to radiate authority, respect, and hope.

Sometime shortly after 3 August 1903, George Sarton notes in his diary how he wants to be remembered: He loved beauty and life, but he did not fear death. He wrote little but thought a great deal. He acted well in life. He was a friend of order, in a general sense, a friend of progress, above all a friend of logic and precision. In 1922 he emphasizes: When people will ask 50 or 100 years hence what I did, I hope they will be told: He founded the history of science, he established it as an independent and organized discipline.(68) On the eve of rejoining his family in Europe in 1925, his life has indeed been played out according to his desires. At age 41 George was still evolving emotionally; Mabel, at 47, was philosophical. Money was a continual worry. After spending more than half a year in Europe away from George, Mabel writes that she fears that the happiness of seeing him again will be denied her. George the rationalist is unsympathetic: I do not believe in forebodings except as indication of real conditions. Mabel's letter frightens George. Never again does he want to be separated from her for so long: We have thrown away a year of common happiness.(69)

Making allowances for time and place, the Sartons in 1925 are not unlike their beloved Carlyles 90 years earlier, when Thomas Carlyle, having just rewritten *The French Revolution* from memory at age 40 (the original manuscript having accidentally been burned in the house of John Stuart Mill), was turning down offers of employment as he struggled to make ends meet. Since his twenties, Thomas Carlyle hoped for an academic appointment at the universities of Edinburgh, London, St Andrew's, and Glasgow in everything from mathematics, physics, and astronomy to moral philosophy, rhetoric, and metaphysics; George knocks on doors across Europe and America, asking for a permanent professorship. (Their ambitions are gratified only late in life.) In 1835, Thomas Carlyle vacationed in Scotland away from his wife, Jane; in 1925, Mabel spends much of a year in Europe away from George. Thomas Carlyle's remarkable work in the present tense appeared in 1837, the first volume of George's landmark *Introduction to the History of Science* in 1927.(70) Jane Welsh Carlyle was known and liked as the intellectual equal and firm supporter of her husband Thomas. In the same way, and notwithstanding her desire for an independent identity, Mabel Elwes Sarton provided support and understanding without which, it is safe to conclude, George Sarton would have lost his way.

Throughout her life, Mabel meditated on the meaning of love. Her

affection for George grew deeper at the end. On 26 August 1946 she wrote about it in her characteristic way of connecting small particulars, crossed meaning in a conversation with husband and daughter, with large themes:

> I am writing this because I shall not have a chance before you leave in the morning & it is during the night that I decided I must tell you something of what is in my heart. How are you to know otherwise?BI know so little still of what is in *your* heart because it is not in your nature to open it wide even to me.
>
> I have hesitated more than once to speak of some little thing I had done that I suspected hurt you because I felt it was best for *you* to let it be forgotten quickly, but twice over the last days I have seen a hurt look in your clear face that has haunted me.
>
> You did not understand how it was we laughed when you began telling the story of Mrs Mussolini; you see you used the expression only the big tops were to go to the ceremony. Now I think you meant the 'big bosses' but this expression big tops was extremely expressive & *funny* & quite new, a Sartonesque invention! & it set a *mood* for the story which was entirely wrong. Now that was not our fault, nor of course *yours*. But it hurt you, & the more so that we were *two* against *one*, You must not feel this. I am for you *both*. I love you both with yearning for your happiness, but you, my husband are more necessary to *my* happiness than May, dearly as I love her. I can let May go to live far away if necessary, I cannot imagine what life would be if you went away.

On Christmas morning 1948, after undergoing an operation for the recurrence of breast cancer,(71) Mabel writes to George:

> I have been thinking of you, and of this last year, and remembering how it troubled me that last night in hospital before the operation that I had never told you *how happy* I have been; I have sometimes tried to tell you how I loved you, & for this there are other ways than the poor way of words: (just the *tone* of your voice when you call me Mother dear, the tragic, *bereft* look in your eyes when you left me in that hospital room, these told me more than even your dearest words & so I hope it has been with you), but to convey to you, the rare not to be measured, happiness, that you have given me, that does need to be said, or you might never guess how deep it was (& if I had died, one of my last bitter thoughts would have been he will never know), but as I lie thinking of this, I realize that happiness is something that refused to be caught in any net of words, that as May says in her poem Growth of happiness, it is an inward, invisible thing as mysterious as life itself, nourished from

> without but also from roots that go wide & deep, far out of sight. In a thousand ways you have nourished those roots, but all I can find to say is how happy I have been because of you.
>
> One more thing I'd like to tell you: I am humbled, by what people write about my courage: I believe that there is a sort of miracle still granted to us, by the faith we place in those we love: When People believe us to be better than we are, we become better, in a quite extraordinary degree. Because you & May counted on me to be of good courage, it helped me, & continued to help me, to have at least *some*, so go on believing me to be much better than I am! (I am often impatient, sometimes discouraged, but never mind! Often the mood passes, with the help of your confidence in me.)

Like her husband, Mabel Sarton associated love with creative work. She comments in a letter of 14 January 1928:

> Yes, it is very true that to lose oneself utterly in love or work or play is to be purely happy, but the remembrance of love, (not its deliberate analysis) can have a poignant, trembling loneliness of its own, like the reflection of a star in a deep pool, & there is a pure & almost impersonal joy in the realization that some piece of one's work is beautiful and true, a joy which nothing can surpass, it is literally a divine gift, undeserved possible? One does not feel any person aggrandisement, rather a kind of illumined humility. One works & works with intensity (or laboriously) with a sort of blindness that gropes & struggles & suffers & doubts, & then one day, out of the rough incompleteness, emerges a blossom, a crystal of truth, that you have to recognize as such, with a throb of joyful recognition. It does not so much matter that it be a large & important thing, or a small & to other men's eyes, insignificant thing, so long as, within its scope, it has this quality of completeness. It does not come often, but seems to me the very reason of living. I get it once in a while, with my work of designing. I would starve if I never had it.

George knew at least that Mabel was his compass. On the day of Mabel's death, George writes to his old friend Horace Kallen about a commitment to lecture at the New School in New York. Mabel will die very soon, George reports, but her death will not prevent me from doing my duty in N.Y. next Sunday. He continues: My life has been a torture during the whole summer & autumn. We have been married almost 40 years, without ever a cloud except her poor health.(72) A dispassionate observer of George and Mabel Sarton might gloss, If never a cloud, then surely lightning struck out of the blue. Absent is Carlyle's remorse at the pain he caused his wife, just as George had

ignored the remorse nearly 40 years earlier, even though he received periodical warnings about it from Carlyle's French translator. When George was struggling with placing his journal *Isis* on its feet, Emile Masson advised: Friend, why not leave off *Isis* for Mabel, now and again? Remember Carlyle. Remember Jane Welsh, notably *Reminiscences*. What a lesson, *grande & terrible*.(73) George reserved for himself and Mabel an apotheosis resembling the one his early inspiration Auguste Comte conferred on Clotilde de Vaux.(74)

In his chosen discipline, George Sarton was a buccinator, an advocate, but those who mattered in the calling knew George's measure. The forum, which George tirelessly addressed, dignified his undertaking: *Newsweek*, in 1947, called him the world's leading historian of science; shortly after his death, an advertisement for women's fashions in *Vogue* featured a twiggy model carrying a Dover edition of two of his short books.(75) The first volume of George's *Introduction* sealed his fate in America as a scholarly generalist. His great circle of colleagues provided a turbulent education for his daughter May and a continuing stream of dazzling personal contacts for his wife, a recognized commercial designer in America and in Europe whose talents were sought by élite private schools.(76) Science progressed, of that George was sure. But it was above all in his marriage where George Sarton measured his personal progress by experiences shared and truths won.

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Sources and Endnotes

Correspondence cited between George and Mabel Sarton is found in the Berg Collection of English and American Literature, The New York Public Library, Astor, Lenox and Tilden Foundations, New York; when no indication is provided in the notes, this is where the material may be found. The Papers of May Sarton, Series XV Family Papers 1846-1993, Boxes 171-182, also in the Berg Collection, contain George Sarton's unpublished biography of Mabel Sarton, Adventures of a Scholar's Wife, and other Sarton correspondence (abbreviated NYPL in the notes). George Sarton's diary (Diary) and agenda (Agenda) are located in Houghton Library of the Harvard College Libraries (HGS). Correspondence between George Sarton and his employers is in the archives of the Carnegie Institution of Washington (CIW). The Lucy May Stanton Papers are located in the Hargrett Library of the University of Georgia, Athens (ALS). Miscellaneous documents have been viewed in the home of the late May Sarton at York, Maine

(YMS); most of them are now located in the May Sarton Papers at the New York Public Library. All illustrations come from the private archive of Susan Sherman, Riverdale, Bronx, New York.

1.James Surowiecki, Bring on the Nanobubble, *New Yorker*, 15 March 2004, p. 68.

2.Margot Peters, *May Sarton: A Biography* (New York, 1997), pp. 168, 296.

3.Max Weber, Science as a Vocation, in *Max Weber's >Science as a Vocation,'* ed. and trans. Peter Lassman, Irving Velody, Herminio Martins (London, 1989), p. 8.

4.Suzanne Lilar, *Aspects of Love in Western Society,* trans. Jonathan Griffin (London, 1965), Introduction and p. 23.

5.Dominique de Bray [George Sarton], Songerie sur la musique, *Revue bleue, 2* (1904), 380-4. George writes his pseudonym in his agenda on 15 March 1903 (HGS). The novel is Fromentin's *Dominique*, a favorite of the narrator in George's unpublished novel, *Petite Amie*, also titled *Lettres d'un enfant sur la sagesse et la vie*, a work dedicated to Goethe. Rough and fair copies inserted in Diary, September 1904 (HGS). On 23 and 24 February 1904 George notes that he has read Fromentin's work of art criticism *Maîtres d'autrefois: Belgique-Holland* for the third time (the 13th edition appeared in 1904).

6.These are some of the issues discussed by Phyllis Rose in her study, *Parallel Lives: Five Victorian Marriages* (New York, 1983). The marriages are those of the Carlyles, the Ruskins, the Mills, the Dickenses, and George Eliot and George Henry Lewes.

7.Edward Shorter, Female Emancipation, Birth Control, and Fertility in European History, *American Historical Review, 78* (1973), 605-40; Ansley J. Coale and Roy Treadway, A Summary of the Changing Distribution of Overall Fertility, Marital Fertility, and the Proportion Married in the Provinces of Europe, in *The Decline of Fertility in Europe: The Revised Proceedings of a Conference on the Princeton European Fertility Project*, ed. Ansley J. Coale and Susan Cotts Watkins (Princeton, 1986), pp. 31-181.

8.The best treatment of women in science around 1900 is José Manuel Sánchez Ron, *El Poder de la ciencia* (Seville/Madrid, 1992), pp. 171-92, which presents comparative statistics and data about the European and United States experience. The marriage of scientists and physicians is considered in Helena M. Pycior,

Nancy G. Slack, and Pnina G. Abir-Am, eds, *Creative Couples in the Sciences* (New Brunswick, N.J., 1996). The book focuses on English-speaking people in the North Atlantic World during the late-nineteenth century and early twentieth century, omitting figures like Emil Bose and Margrete Heiberg de Bose in Germany and Argentina, Etienne Vassy and Arlette Vassy-Tournaire in Morocco and France, and Jacob Clay and Tettje Clay-Jolles at Bandung and Bernardus Jan van der Plaats and Agathe van der Plaats-Keyzer at Batavia, the latter couples on Java. Generally, Marilyn Oglivie and Joy Harvey, ed., *The Biographical Dictionary of Women in Science* (New York, 2000), with 2500 entries.

9.May Sarton, *The Bridge of Years* (New York, 1946); *I Knew a Phoenix* (New York, 1959); *A World of Light* (New York, 1976). George and Mabel Sarton figure in May's fiction as well as in May's non-fiction. See Margot Peters, *May Sarton: A Biography* (New York, 1997).

10 .Arnold Thackray and Robert K. Merton, On Discipline Building: The Paradoxes of George Sarton, *Isis, 63* (1972), 473-95, p. 490. By this assessment, the authors mean that George was not a great prose stylist. The phrase is ironic, given that they emphasize George's positivistic, progressivist view of history of science, lending support, inaccurately I believe, to identifying George as a Whig historian. In a manifesto about history of science, George cites Thomas Babington Macaulay to the effect that judging the past requires freedom from the prejudices of the present: George Sarton, The New Humanism, *Isis, 6* (1924), 9-34, on p. 30.

11.Among the brightest introductions are Noel M. Swerdlow, Montucla's Legacy: The History of the Exact Sciences, *Journal of the History of Ideas, 54* (1993), 299-328; José María López Piñero, Las Etapas iniciales de la historiografía de la ciencia: Invitación a recuperar su internacionalidad y su integración, *Arbor, 142*, nos 448/559/560 (1992), 21-67. Earlier appraisals by senior scholars include Helge Kragh, *An Introduction to the Historiography of Science* (Cambridge, 1987); Arnold Thackray, History of Science, in *A Guide to the Culture of Science, Technology, and Medicine*, ed. Paul T. Durbin (New York, 1980), pp. 3-69; I. Bernard Cohen, History of Science as an Academic Discipline, in *Scientific Change*, ed. A. C. Crombie (London, 1961), pp. 769-80; and José Babini's excellent study, *Ciencia, historia e historia de la ciencia* (Buenos Aires, 1967).

12.While working in Washington, Mabel Sarton energetically intervened on behalf of George in the spring of 1918, when George was desperately seeking a renewal of his contract at Harvard University or another suitable position. In particular, she lobbied with the Belgian Embassy to hire him. Mabel Sarton to

George Sarton, 9 March 1918, referring to E. de Cartier, former Belgian ambassador to China: Some instinct keeps telling me to warn you against landing yourself at Harvard because I feel & believe that De Cartier will want you. He certainly gave Dr Baekeland the impression that he would like to use your abilities & your sympathies for & knowledge of the best American ideas. Mabel mentions dining with the T. Wayland Vaughans. Vaughan, a product of Tulane and Harvard universities who studied music in Europe, is a federal sedimentologist who eventually directed the Scripps Oceanological Institute. A boring speaker, according to George, whose daughter was a friend of the Sartons' daughter May. Mabel also writes that she has arranged to speak with De Cartier over lunch on 14 March, a meeting to which George, then at Harvard, is also invited. Mabel's support figures explicitly in George's eventual appointment with the Carnegie Institution of Washington. Historian of science William Sedgwick, recommending George to the Carnegie Institution's Robert Simpson Woodward, emphasizes that George has also an English wife who heartily seconds his endeavours. Sedgwick, who serves on the advisory council of the Shady Hill School where May is a pupil, knows first-hand about the Sarton family. CIW, William Sedgwick to Robert S. Woodward, 24 April 1918. Margot Peters, *May Sarton: A Biography* (New York, 1997), p. 404.

13.NYPL, Mabel Elwes to Céline Dangotte, 6 April 1899.

14.John M. Robertson, *Modern Humanists: Sociological Studies of Carlyle, Mill, Emerson, Arnold, Ruskin, and Spencer* (1891; Port Washington, N.Y., 1968).

15.NYPL, Mabel Elwes to Eleanor Elwes, March 1907.

16.Adventures of a Scholar's Wife. In 1914 George notes a biography of Conway, the general thinker and noble pilgrim. George Sarton, John M. Robertson, *The Life Pilgrimage of Moncure Daniel Conway*, *Isis, 2* (1919), 450 (the issue was composed before the First World War). Well before then George looked into things Oriental. In his agenda on 4 May 1904, he notes Charles Holme's article, Japanese Flower Painting, *The Studio*, 15 April 1904. George is likely the G.S. from the University of Ghent who authored a poem, O'Kama d'Osaka, on pp. 378-9 of the *Almanach de l'Université de Gand* for 1904, published by the Société générale (fédération) des Etudiants libéraux. It is a Japanese legend about a woman who suffers the death of her lover.

17 .In helping to choose a name, Mabel may have thought back to a similar-sounding journal for which she was artistic consultant in 1908: *Iris: Vrij,*

algemeen nederlandsch maandschrift; prospectus in NYPL. George elaborates various precedents in Why *Isis*? *Isis, 44* (1953), 232-42. The most persuasive is a book by James Teackle Dennis, *The Burden of Isis, Being the Laments of Isis and Nepohythys* (London, 1910), which George bought in Ipswich, England, during a happy visit in 1910 with Mabel. Diary, 25 February 1953, for Dennis. George does not appeal to theosophy, to which he was introduced as a student. Jean Delville, an innovative artist whom George admired, advises in a letter of 20 September 1906, You are ready for the study of *theosophy* (HGS). The formulator of theosophy, Helena Petrovna Blavatsky, set down her early doctrines in the book, *Isis Unveiled: A Master-Key to the Mysteries of Ancient and Modern Science and Theology* (London, 1877), among many editions.

18.Scholar's Wife.

19.Riverview, Bronx, New York, private archive of Susan Sherman. Ex-libris, designed by Mabel Sarton for George Sarton, as recorded in George Sarton's diary, 31 August 1920. We may read the prominent nipple profile as an assertion of the artist's independence. By the 1970s, the History of Science Society preferred a sexless hieroglyph. Rosemary Regan and Richard H. Schallenberg, ed., *History of Science Society Directory of Members and Guide to Graduate Study* (New York, 1977), the cover illustration.

20.Mabel attended the Institut Charles de Kerchove, in Ghent. Taking its name from the middle 19th-century liberal mayor of Ghent, Charles de Kerchove de Denterghem, it was a private *école primaire supérieure*, or finishing school, seeking to provide girls with a broad and general education. Mabel boarded there as an *élève libre*, that is, a student who does not follow the prescribed curriculum for a diploma. The curriculum included a full range of humanities and sciences, along with domestic arts and fine arts. The school engaged a number of university professors as lecturers, and among Mabel's teachers were Frédéric Swarts, a pioneer in the study of fluorine compounds who would later teach chemistry to George Sarton at the University of Ghent; Ernest Discailles, who taught French and Romance literatures to George; and historian Paul Fredericq. Mabel remembered her teacher of French poetry, Adèle Dupuis, and also Joseph de Smet, the historian of art who introduced Lafcadio Hearn to French readers. The Institut de Kerchove around 1900 is recorded in documents contained in Fonds Vliegende Bladen IE28 Ecole in the University Library of Ghent. The documents are a donation of Paul Fredericq. I am grateful to Head Librarian Sylvia van Peteghem for access to this material. When Mabel's father died in 1906, she joined the household of her friend Céline Dangotte, whose parents owned one of the premier

retail establishments in Ghent for domestic wares, Adolphe Dangotte, which under Céline Limbosch-Dangotte expanded into an ambitious undertaking in interior design, L'Art décoratif. HGS, Céline's father Léopold Dangotte to George Sarton, 24 June 1910: I adore Mabel and regard her as a second daughter.

21.George Sarton, Knowledge and Charity, *Isis, 5* (1923), 5-19.

22.HGS, Alfred Hoernlé to George Sarton, 12 June 1923.

23.Emile Masson, George Sarton et le Nouvel humanisme, *Les Humbles*, no. 10 (February 1919), 7-19, on p. 19. Masson refers to the Madonna from the Inn's Hall, 1433, presently in the National Gallery, Melbourne, Australia. The periodical is a revue de Jeunes. HGS, Emile Masson to George Sarton, 10 January 1919.

24.George Sarton, Why Isis? *Isis, 44* (1953), 232-42, on p. 236; George Sarton, Matériaux pour l'histoire de l'art asiatique (première série), *Gazette des beaux-arts, 8* (1923), 1-17; George Sarton, Art as an Approach to Asia, *Yale Review, 15* (1926), 540-52.

25.George talked with Daniel F. Comstock about ways to investigate psychical phenomena. Diary, 6 July 1920. Comstock was a physicist at MIT until 1917, when he devoted all his effort to an independent laboratory that in 1922 developed Technicolor. Stanley Goldberg, *Understanding Relativity: Origin and Impact of a Scientific Revolution* (Boston, 1984), p. 250. William McDougall arrived at Harvard from England in the fall of 1920 to occupy the chair held by William James and then Hugo Münsterberg. He was a firm advocate of eugenics and of the primacy of inherited characteristics, and he championed the instinctual pursuit of indistinct goals. McDougall disliked behaviorism and materialism, and like William James, he was attracted to spiritism as a topic worthy of serious, experimental inquiry. (Mabel, on 9 August 1921, writes to George about a psychic at Intervale who produced a message from William James, Jr, to William McDougall.) From his arrival in America, McDougall remained aloof from most of his colleagues, who conspired against him, and in 1927 he moved to Duke University, where as chair of psychology he actively promoted the research of Joseph Banks Rhine and Louisa Weckesser Rhine in parapsychology. The Sartons and the McDougalls found much in common as cultured Europeans who were marginalized at Harvard, although George notes to Mabel on 15 August 1921, I hardly know them. Seymour H. Mauskopf and Michael R. McVaugh, *The Elusive Science: Origins of Experimental Psychical Research* (Baltimore, 1980),

pp. 59-70 on McDougall.

26.NYPL. The published version: George Sarton, An Institute for the History of Science and Civilization, *Science, 45* (1917), 284-6; *46* (1917), 399-402 for a second installment. At this time Mabel wrote letters for George's institutional schemes. HGS, James Harvey Robinson to George Sarton, 23 November 1916, thanking George for the letter Mabel wrote on his behalf for coordinating the contributions that are being made to the history of science; George Lincoln Burr to George Sarton, 8 September 1917, apologizing for not answering his letter from Mme Sarton writing on your behalf. Burr sees no way to realize George's plan.

27.George Sarton, The Message of Leonardo, *Scribner's Magazine, 65* (1919), 531-40. The editor at *Scribner's*, Robert Bridges, paid George $200 for the article. HGS, Robert Bridges to George Sarton, 15 February 1919.

28.George gave power of attorney to his biologist friend Paul Pelseneer, who opened George's box in the bank vault in 1919. HGS, Paul Pelseneer to George Sarton, 8 May 1919.

29.NYPL, Eleanor Elwes to Mabel Elwes, ca 1901.

30.A telephone at the Sartons' Wondelgem residence is inferred from a letter of 27 June 1913, where George Sarton writes to Mabel Sarton about the phospholipid lecithin (at the time extracted from egg yolks) that she was taking, apparently for anxiety. He comments that she may telephone the pharmacist for more of the substance if her physician, Adolphe Miele, does not give it to her. In the middle of the nineteenth century, phosphorus was held to be essential for mental functions. The contention found decreasing support by the eve of the First World War. Miele's prescription of lecithin for mental imbalance was a conservative, even outdated therapy. Theodore L. Sourkes, An Element of Thought: Phosphorus and Mental Philosophy in the Nineteenth Century, *Journal of the History of the Neurosciences, 7* (1998), 108-24; Sourkes, The Discovery of Lecithin, the First Phospholipid, *Bulletin of the History of Chemistry, 29* (2004), 9-15. A telephone at the Sartons' residence in Cambridge, Massachusetts, is inferred from a letter of 3 August 1917, where George Sarton writes to Mabel Sarton about his gift to her of a little book for telephone numbers.

31.HGS, David Eugene Smith to George Sarton, 21 December 1912.

32.Diary, 4 April 1921. George and Mabel draw up a list of books for their Ideal

Library, not being able to afford to buy them. Included are Sir Henry Maine's *Ancient Law*, Louis Hémon's French-Canadian classic *Marie Chapdelaine*, and works by Gustaf af Geijerstram, Giovanni Papini, Selma Lagerlöf, Lytton Strachey, Serge Aksakoff, Ferenc Molnar, Edmund Gosse, Evangeline Wilbour Blashfield, Godfrey Rathbone Benson (Lord Charnwood), Herbert G. Ponting, Jérome and Jean Tharaud, Felix Timmermans, and George Borrow.

33.Paul van Oye, *George Sarton: De Mens en zijn Werk uit Brieven aan Vrienden en Kennissen* (Brussels, 1965) [*Verhandelingen van de Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België, Klasse der Wetenschappen, 27*, no. 82], p. 49.

34.CIW, George Sarton to Robert S. Woodward, 25 August 1918, for the loathsome counterfeit of admiration for heroic figures by *snobbish* & crazy women, but men are also objects of George's derision: No amount of knowledge will give generosity and intelligence to a man who has none. On the contrary, it will set his pettiness in greater contrast, in the same way that wealth makes mediocrity more conspicuous. George Sarton, Secret History, *Scribner's Magazine, 67* (1919), 187-92, on p. 189. George also declaims against male snobs, the vanity and the snobbism of so many men, who are aroused by the incessant desire to be spoken about. George Sarton, L'Organisation scientifique du journalisme, *La Vie internationale, 5* (1913), 391-428, on p. 412. And later: But even this wretch of a snob is not as depersonalized as he seems....Once his snobbery has been pierced through, he is as unable to hide his real self as any professional actor. George Sarton, Transparency: A Way of Looking at People, *Scribner's Magazine, 77* (1925), 308-313, on p. 311.

35.HGS, Henri Lafontaine to George Sarton, 26 July 1915, for Lafontaine's comments on Alfred Hermann Fried's views, transmitted by George, about the Central Powers as victims of militarism; Lafontaine to Sarton, 13 August 1915, for skepticism about a Paneuropean political structure.

36.Diary, 16 November 1915.

37.*Isis, 1* (1913), 320: under Sciences des primitifs in the analytical bibliography, Sigmund Freud, Der Wilde und der Neurotiker, *Imago*, nos 1, 3, and 4 (1912); George Sarton, Sigmund Freud, *Leonardo da Vinci: A Psycho-Sexual Study of an Infantile Reminiscence, Isis, 3* (1920), 104.

38.Peters, *May Sarton.*

39.NYPL, Mabel Sarton's health records. One form of sex-hormone treatment at the time consisted of powdered corpus luteum, derived from domestic animals, taken orally with meals. It was indicated for neurasthenia as well as for menstrual bleeding. B. A. Thomas and R. H. Ivy, *Applied Immunology* (Philadelphia, 1915), p. 316. In the first decade of the twentieth century, dried ovarian substance was commercially available and used to treat nervous and emotional disorders, including delusional insanity, associated with conditions diagnosed as ovarian in origin. H. Batty Shaw, *Organotherapy, or Treatment by Means of Preparations of Various Organs* (Chicago, 1905), pp. 203-4.

40 .Auguste Forel, *Die sexuelle Frage: Eine naturwissenschaftliche, psychologische, hygienische und soziologische Studie für Gebildete* (Munich, 1905). Mabel undoubtedly read a French edition, for example, *La Question sexuelle: Exposée aux adultes cultivés* (Paris, 1906). Forel's socialist sympathies would have attracted George and Mabel. Notably, Forel persuaded the Belgian socialist Emile Vandervelde to become a teetotaler. Emile Vandervelde, *Souvenirs d'un militant socialiste* (Paris, 1939), p. 136. Albert Einstein's path intersects that of the Sartons at a number of points (Mabel was in Zurich when Einstein was a professor there), and this is one of them; Albert Einstein's first wife Mileva Mari read and annotated *Die sexuelle Frage*, notably a passage in the section on Utopian ideas about ideal marriage in the future: Husband and wife will have learnt to find the truest satisfaction in the accomplishment of their different duties, and in their work in common for the benefit of society. Michele Zackheim, *Einstein's Daughter: The Search for Lieserl* (New York, 1999), p. 270.

41.George Sarton, Iwan Bloch, *Die Prostitution*, *Isis, 1* (1913), 284-5.

42.George Sarton to Mabel Elwes, Pentecost 1908, where he resigns from the Bons Templiers, although George writes to Raymond Limbosch on 17 May 1908 that he is still a member of the Order. Van Oye, *George Sarton*, p. 53. NYPL, Arthur Sarton to George and Mabel Sarton, 16 July 1913, where George and Mabel are still vegetarian. When they leave Belgium, the Sartons progressively abandon vegetarianism, and George once more enjoys alcohol.

43.Osbert Burdett, *The Two Carlyles* (Boston, 1931), pp. 292-3.

44.Charles Richard Sanders, ed., *The Collected Letters of Thomas and Jane Welsh Carlyle*, vol. 1 (Durham, 1970), p. xxiv for the number. The untrustworthy Frank Harris, for example, reports Jane Carlyle's virginity after 25 years of marriage. John Stewart Collis, *The Carlyles* (New York, 1971), pp. 181-2 for Harris; also

Rosemary Ashton, *Thomas and Jane Carlyle: Portrait of a Marriage* (London, 2003), p. 11. In the absence of documentary evidence, the union of sociologist Max Weber and Marianne Weber both prolific writers, is also suspected to have been unconsummated. Donald G. Macrae, *Max Weber* (New York, 1974), p. 24; cf Patricia Madoo Lengermann and Jill Niebrugge-Brantley, *The Women Founders: Sociology and Social Theory, 1830-1930* (Boston, 1998), p. 214 for the contrary assertion.

45.Ashton, *Thomas and Jane Carlyle*, p. 76. Ashton adds: All we can say is that no positive proof of consummation survives, but then, apart from pregnancies and children, of what could such proof consist?

46.Noel Annan, *Our Age: English Intellectuals between the World Wars, A Group Portrait* (New York, 1990), p. 86. With the Sartons, George tracked Mabel's period, but it was Mabel who made the connection between menstruation and her emotional state.

47.Van Oye, *George Sarton*, pp. 110-11.

48.Virginia Woolf, *Carlyle's House and Other Sketches*, ed. David Bradshaw (London, 2003), pp. 4, 49.

49.In 1925, when she lived and worked in Belgium, Mabel designed an altarpiece for the exhibition held that year in Paris devoted to the decorative arts; she received a gold medal for it. Mabel Sarton to George Sarton, 15 February 1925; May Sarton, *A World of Light: Portraits and Celebrations* (New York, 1976), p. 60. NYPL, Madeleine van Thorenburg to Mabel Sarton, 18 December 1925, congratulating Mabel for the gold medal.

50.F[erdinand] K[hnopff], Studio Talk, *The Studio, 51* (1910-11), 324-8. Mabel writes to her friend Marthe Patyn on 28 November 1910 (NYPL) that her embroideries will be featured in an upcoming number of *The Studio*:
I had brought them to London to try to obtain orders from one or another of the large companies. Then I fell sick and despaired of not having accomplished anything. And then the idea occurred to send them to the publisher of *The Studio* with a letter simply describing them and saying that I thought that he would like to see them. He was more or less prepared, because Fernand K[h]nopff should have written to him, and an article on the cottage was projected. He asked me to keep them for several days to photograph them!

51.HGS, Leopold Dangotte to George Sarton, 24 June 1910.

52.George Sarton to Mabel Sarton, 30 December 1914.

53.In his agenda for 15 January 1904, George notes the utility of *états tampons* for world peace.

54.The *Independent* rejected the proposal on 8 October 1914; the Sartons received the rejection in Cambridge, Massachusetts, on 24 February 1919. YMS.

55.Hendrik Christian Andersen, A World Center for Peace, *Independent, 84* (October 1915), 152.

56.George Sarton, La Conscience mondiale, *Isis, 1* (1913), 488-9. Hendrik Christian Andersen, *Creation of a World Centre of Communication* (Paris, 1913), historical part by Gabriel Leroux, architectural part by Ernest M. Hébrard and Jean Hébrard. HGS, Hendrik C. Andersen to George Sarton, 11 September 1913, sending along the introduction to *Creation* for review in *Isis*. On the internationalist city-planners: Giuliano Gresleri and Dario Matteoni, *La città mondiale, Andersen, Hébrard, Otlet, Le Corbusier* (Venice, 1982); Annick Brauman, The Parc Léopold: The Home of Scientific Imagination, in *The History of Garden Design*, ed. Monique Mosser and Georges Teyssot (London, 1991), pp. 442-4.

57.Sarton, The Future of Belgium, pp. 263, 270, 271.

58.HGS, Hendrik C. Andersen to George Sarton, 10 July 1915.

59.George Sarton, Emile Waxweiler (1867-1916), *Nation, 104* (1917), 168-9.

60.ALS, Mabel Sarton to Lucy Stanton, 15 December 1928. On 6 April 1930 Mabel calls herself a sister-friend in a letter to Stanton; on 20 February 1931 she signs herself always your loving sister.

61.May Sarton recalls: Lucy Stanton came into our lives like an angel at a time when perhaps we were all three rather lonely....My father, always sensitive to the charm of women of character, basked in her warmth. May Sarton, Lucy Stanton, a glimpse of her seen by a little girl, June 1966, ALS. In the early 1920s Lucy Stanton was established in Boston as a teacher of art history and art at Dana Hall in Wellesley, Miss Choate's School, and Milton Academy. George writes in his

diary on 15 May 1921: She is so kind and so sound, and her quiet energy is amazing. I like her. George records tea and dinner with Stanton on 15 September 1921, and he notes her address and telephone number in his agenda, a rare entry. Mabel leaves town on 18 September 1921. In his agenda George indicates coitus on 21, 23, and 28 September 1921. In his diary on 24 September 1921: Lucy Stanton, who is really a dear friend introduces him to Percival Chubb, leader of the St Louis Ethical [Culture] Society, himself an old friend of Havelock Ellis. Mabel leaves for Washington on 2 October at 7:30 p.m. George records coitus. On 30 October 1921 his agenda records dining with Lucy Stanton and walking her back to Boston. Betty Alice Fowler, An Art in Living, in Betty Alice Fowler and Andrew Ladis, *The Art of Lucy May Stanton* (Athens, Georgia, 2002), pp. 16-28, on p. 22.

62.On two occasions a foreign teacher was invited to teach the history of science in H.U. in competition with me and I was not warned or consulted in either case, except (in the second case) *pro forma, in extremis*. The foreigners were Georgio de Santillana and Willy Hartner. Diary, 5 November 1948.

63.Diary, 15 January 1954 and 7 February 1954. From the former: May has published in the latest *New Yorker* a delightful essay derived from my table-talk. It is fairly correct and yet I do not recognize myself, because the period described is too distant in years and vicissitudes. It represents a kind of prehistoric me.

64.George Sarton, La Nouvelle Physique, *Isis, 2* (1914), 193-8, focusing on the Solvay Conferences in quantum physics.

65.They both received an honorary doctorate from Harvard University on 20 June 1935, along with Thomas Mann and George's employer John Campbell Merriam of the Carnegie Institution of Washington--Sarton and Merriam an LLD, Einstein a DSc, and Mann a DLitt. Einstein and Mann Get Harvard Honor, *New York Times*, 21 June 1935, p. 8. George and Albert Einstein were also early members of the Gesellschaft für positivistische Philosophie, led in 1913 by Joseph Petzoldt. *Zeitschrift für positivistische Philosophie, 1* (1913), membership list tipped into the volume in the Graduate Library, University of Michigan. George and Albert Einstein both contributed to *Romain Rolland, Sexagenario ex Innumerabilibus Amicis Paucissimi Grates Agunt*, eds Maxim Gorki, Georges Duhamel, and Stefan Zweig (Zurich, 1926). At the end of his life, George saluted Einstein as a philosopher. George Sarton, Henri Berr (1863-1954): La Synthèse de l'histoire et l'histoire de la science,@ *Centaurus, 4* (1954), 185-97, on p. 192. George writes in his diary on 2 August 1955: AEinstein was a truly great man, not simply because

of his immense discoveries but because of the perfection of his social sense.

66.George Sarton to Mabel Sarton, Pentecost 1908.

67.Horace Meyer Kallen Papers, Jacob Rader Marcus Center, American Jewish Archives, Cincinnati, George Sarton to Horace Meyer Kallen, 5 October 1930.

68.HGS, George Sarton to John Charles Merriam, 1 April 1922.

69.Diary, 3 June 1925.

70.Ashton, *Thomas and Jane Carlyle*, pp. 85-8, 92, 173-4.

71.Mabel Sarton to George Sarton, 31 July 1948, where Mabel reports from Belgium on the discovery of a lump in her breast.

72.YIVO Institute for Jewish Research, New York, Papers of Horace Meyer Kallen, 562/1004, George Sarton to Horace Kallen, 19 November 1950.

73.HGS, Emile Masson to George Sarton, 17 July 1913, referring to George's letter of May. Charles Eliot Norton, *Carlyle intime: Jane Welsh Carlyle, Reminiscences*, trans. Elsie and Emile Masson (Paris, 1913). From the beginning of his correspondence with George, Emile Masson warned George about Carlyle's single-minded devotion to his work, to the detriment of his humanity. Emile Masson to George Sarton, 11 July 1905 (the correspondent is mistakenly identified in HGS as Père Yves Ernest Masson)

74.George Sarton, Auguste Comte, Historian of Science, with a Short Digression on Clotilde de Vaux and Harriet Taylor, *Osiris, 10* (1952), 328-57.

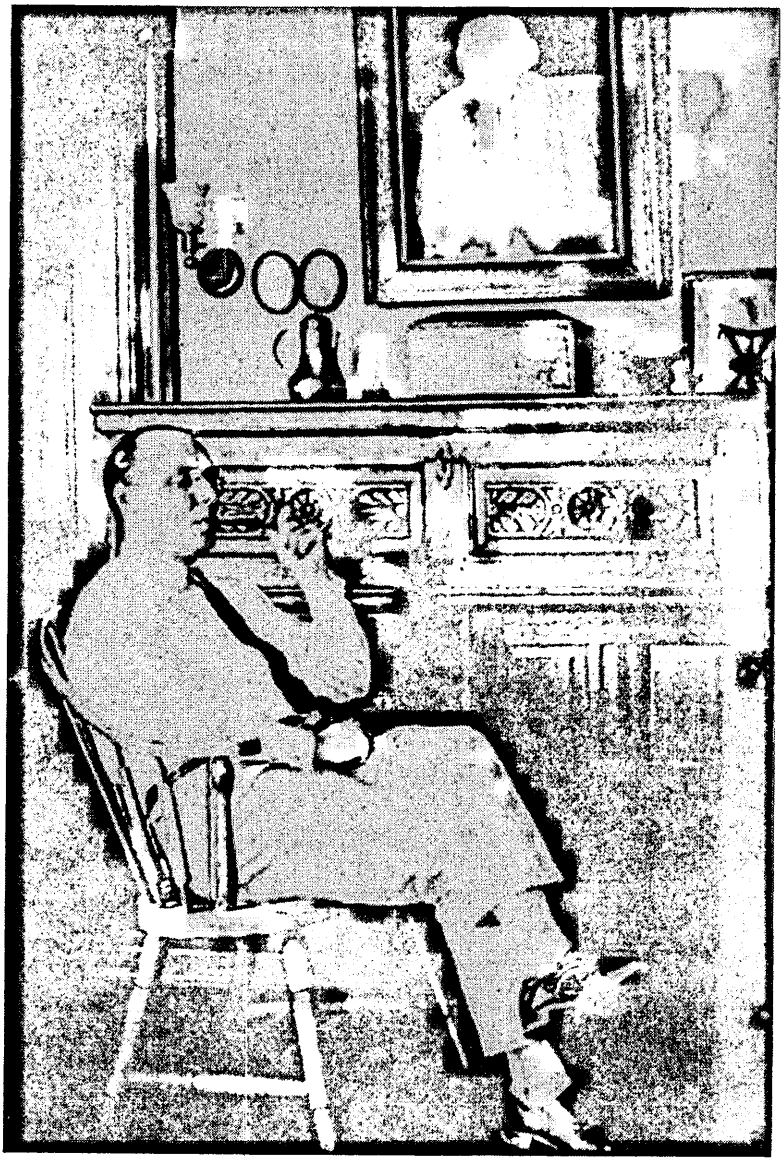
75.Lessons from History, *Newsweek*, 28 April 1947; the *Newsweek* and *Vogue* extracts in YMS. The Dover edition of *The Study of the History of Mathematics* and *The Study of the History of Science* appeared in 1957.

76.In 1915, Mabel was invited to design for Ambrose (later Sir Ambrose) Heal in England. Mabel Sarton to George Sarton, received 6 August 1915. Nikolaus Pevsner, *Pioneers of Modern Design, from William Morris to Walter Gropius* (London, 1974), pp. 154-5 on Heal. In the 1920s, Mabel was an art instructor at the Winsor and Milton schools in Boston.

1. Mabel Elwes, Antwerp, October 1907.

2. Mabel Elwes, *circa* 1920, in a dress of her own design.

3. Young George Sarton, presented to Mabel Elwes on 14 January 1909.

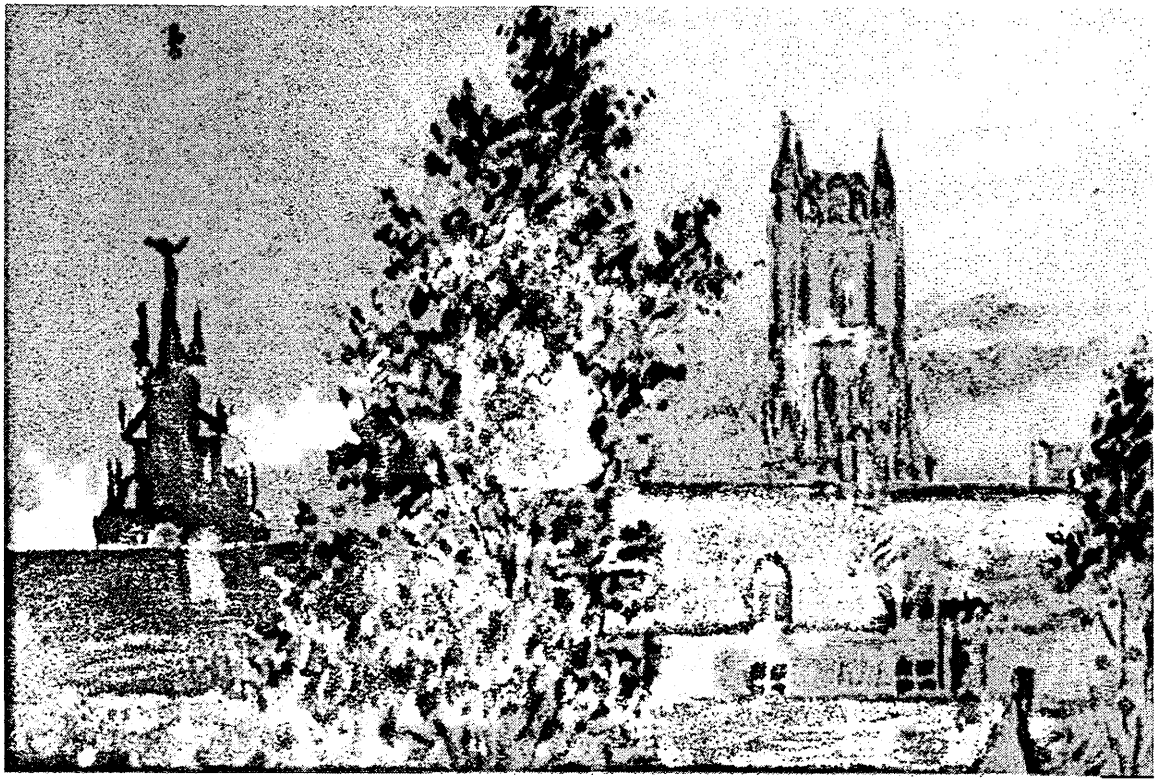


4. George Sarton at home in Cambridge, Massachusetts, presumably 24 Agassiz Street. The oak sideboard and the portrait, probably of the *seigneur* Duvet de la Tour, are likely items given to the Sartons by George's Aunt Hélène, as recorded in George's diary on 15 December 1919.

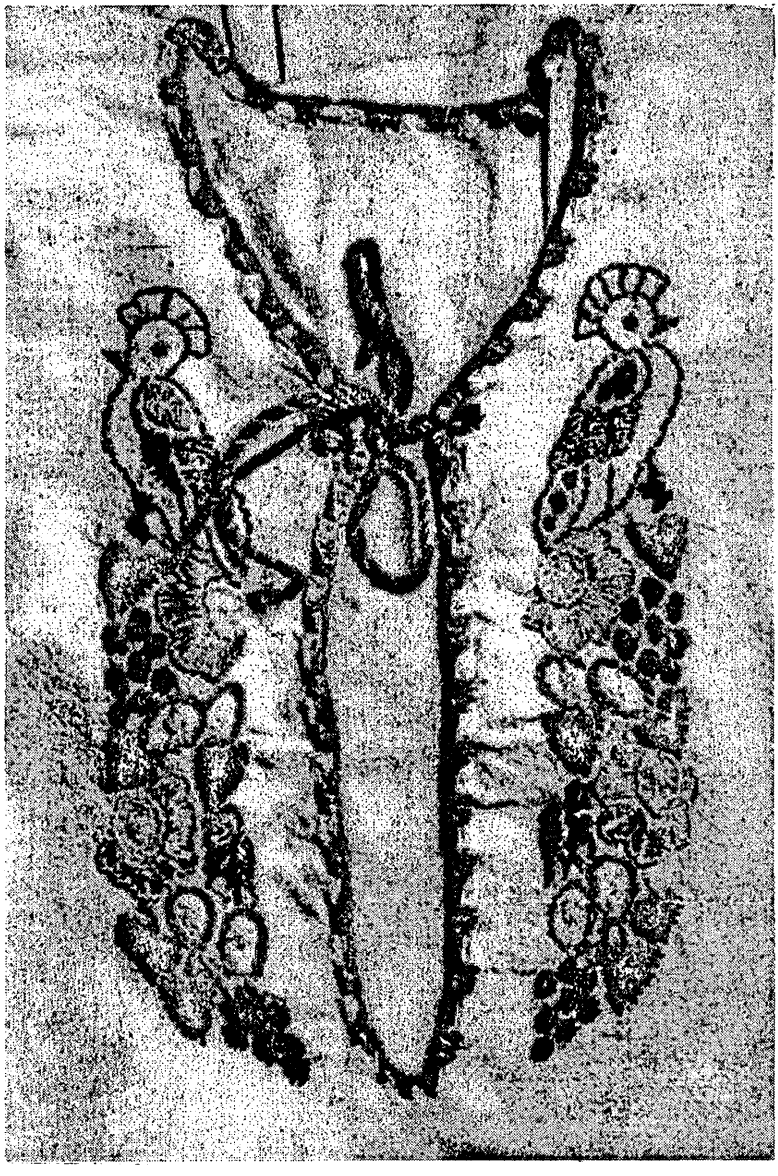
5. George Sarton working at home in Cambridge, Massachusetts. Cats are the Sartons' constant companions in their married life.

6. May Sarton in a dress designed and executed by Mabel Sarton. May Sarton presented the photograph and the dress to Susan Sherman on 29 October 1993.

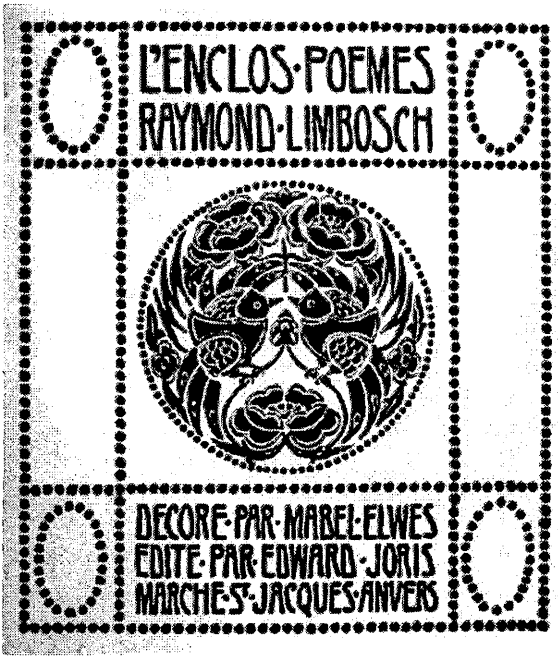
7. De Flinken. The women's society of students and workers in Ghent where were found young Mabel Sarton's closest friends. Left, Marie Mees, Alice van Damme, Marie Praet, Esther Delahaye, Marthe Patyn; right standing, Victoire Ledewyn, Lucie Boulanger; right seated, Mélanie Lorrein, Augusta de Taeye.



8. Belfry (left) and St. Bavon's cathedral, by Mabel Elwes. Mabel Elwes painted this water-color from her lodging in the Dangotte residence atop the Adolphe Dangotte store in the rue du Marais, or Meerstraat, Ghent.



9. Hand-embroidered blouse, avian pattern, by Mabel Sarton.



10. Cover of *L'Enclos*, by Raymond Limbosch. Mabel Sarton's design for the book of poems, published in 1910, shows a bird-and-flower motif. This copy presented by Céline and Raymond Limbosch to Mabel Elwes and George Sarton on 3 December 1910.

11.Ex-libris, designed by Mabel Sarton for George Sarton, as recorded in George Sarton's diary, 31 August 1920. We may read the prominent nipple profile as an assertion of the artist's independence. By the 1970s, the History of Science Society preferred a sexless hieroglyph. Rosemary Regan and Richard H. Schallenberg, ed., *History of Science Society Directory of Members and Guide to Graduate Study* (New York, 1977), the cover illustration.

HUMANITY'S HOPE: HISTORY OF SCIENCE IN THE GOLDEN AGE OF LEARNING

Lewis Pyenson

A generation ago the critic George Steiner began his classic reassessment of T. S. Eliot's *Notes toward the Redefinition of Culture* by observing: Each new historical era mirrors itself in the picture and active mythology of its past or of a past borrowed from other cultures. He continues: Most history seems to carry on its back vestiges of paradise. At some point in more or less remote times things were better, almost golden. In full he observes:

In current Western culture or post culture, that squandered utopia is intensely important. But it has taken on a near and secular form. Our present feeling of disarray, of a regress into violence, into moral obtuseness; our ready impression of a central failure of values in the arts, in the comeliness of personal and social modes; our fears of a new dark age in which civilization itself, as we have known it, may disappear or be confined to small islands of archaic conservationBthese fears, so graphic and widely advertised as to be a dominant cliché of the contemporary mood derive their force, their seeming self-evidence, from comparison. Behind today's posture of doubt and self-castigation stands the presence, so pervasive as to pass largely unexamined, of a particular past, of a specific golden time.

Steiner locates that nostalgia in the nineteenth century, the very time harboring the origins of the inhuman, of the crises of our own time that compel a redefinition of culture.[1] With apologies to Steiner, I propose to locate the Golden Age of scholarship early in the twentieth century, at first glance an unpromising time for it, given the magnitude of atrocities it witnessed in the name of civilization.

Silently present throughout Steiner's analysis is the spirit of Walter Benjamin's Angel of History, seeing catastrophe and destruction but unable to intervene because she is being blown backwards into the future by the same divine wind from paradise that animates the horror.[2] But whereas Benjamin proposes a rectification of hopelessness in an obligation to give life to the unrealized hopes of the past (and in this way invests in the dead past a moral claim on the present), Steiner identifies science as an antidote to *Kulturpessimismus*.[3] At the outset of his inquiry Steiner cites Thomas Babington Macaulay's essay of 1837 on Francis Bacon (to which he might have added Ernest Renan's *Avenir de la science*). He concludes with a

tentative affirmation that, notwithstanding the crimes committed in its name, science is oriented optimistically toward the future: For the humanist, the essential repertoire of his consciousness, the props of his daily life as a scholar or critic are from the past, but for the scientist time and the light lie before. For Benjamin, hope is fleeting and mysterious; for Steiner, hope shall be transmitted to humankind by historians of science, who are able to forge a synthetic future culture.[4] Again with apologies to Steiner, I shall contend that the Golden Age of scholarship radiates this optimistic view of science past.

We owe to Hesiod the location of the Golden Age as a paradise in the remote past, when a race of mortals lived in peace, happiness and abundance. The second age of humankind, the Silver Age, began when Pandora opened her box and freed the host of vexations who had been imprisoned there. Then on to the bronze and heroic ages, each one progressively worse, until the Iron Age of Hesiod's own time, filled with incessant labor and sorrow and marked by ignominious and uncelebrated death. This perennial nostalgia for the Good Old Days, present at the dawn of Greek poetry, may be an artifact of memory, which tends to suppress pain in favor of focusing on pleasure, but it is useful to recall that Hesiod's monotonically decreasing graph of cultural evolution is not the only picture that has come down to us. In dark times, writers hoped for a brighter future. That is, if for Cicero, Tacitus, and Sallust politics focuses not on the best government, in the tradition of Classical Greece, but on the legitimation of power, if the traditional moral authority of the Res Publica has disappeared, then the Golden Age lies not in the republic of the past but rather in the republic of the future; if for Saint Augustine and Thomas More, as for the *marquis* de Condorcet, one's city or one's life is threatened with destruction, the Golden Age of redemption is still to come.

The examples of More and Condorcet suggest that the spirit of revolution can engender fables of a future perfect. This is clear even in the last part of the twentieth century, which has become known as a time of pessimism leading to the denial of all Enlightened tenets notably the existence of truth and facts on the one hand and universal human values on the other hand. In 1969, inspired by the Free-Speech Movement at Berkeley and the Counterculture generally, the distinguished molecular biologist Gunther Stent contended that technological advances heralded a Golden Age in the image of a psychedelic, Polynesian-styled paradise, where hard labor and disease shall be unknown, and where, as well, the impulse to innovate shall fade away.[5] This view has not come to pass, of course, even though it is promoted by prominent writers with an anti-technocratic bent, such as John Ralston Saul and Václav Havel.[6]

By identifying the first part of the twentieth century as a Golden Age

of learning, I do not mean to suggest that everything in this time is of great value or significance. A consideration of the great mass of inaugural dissertations produced in Europe over the years 1895-1925 is sufficient to disabuse even the most enthusiastic supporter of such a thesis.[7] Yet we recognize those works as near-contemporaries in style, structure, and *apparatus criticus*. Writers active in that time are discussed today with an immediacy that is redolent of nostalgia. Beneath my identification of this Golden Age is the thought that some of its featuresBnotably the search for truth and a sense of ecumenism--can usefully be kept in mind by writers today. That prospective, which is best done cautiously, is for another place. The past is not a beast of burden for carrying one's hopes into the future. (In a television interview from many years ago, writer John Updike quoted Voltaire: When you set off on the road to posterity, travel light.) Furthermore, rehabilitation is just short of rebirth, and we may be cautioned by Arnold Toynbee's remark that all calls for a renascence depend on the dark art of necromancy.[8]

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In commenting on the history of religious missionaries over the past several centuries among whom are found the most vigorous promoters of the imperial designs of European powers--Ryan Dunch has recently challenged the explanatory value of cultural imperialism. He seeks to transcend three limitations of what is, evidentally, a diffusionist model of authority. The first limitation concerns a reification of national or cultural authenticity; the second limitation is a neglect of the culture that is subject to diffusionist pressure; the third limitation involves the laminar flow of diffusion, reducing a complex set of interactions to a dichotomy between actor and acted upon. Dunch contends that missionaries foster cultural differentiation in the very act of disseminating concepts claiming a universal' validity, whether...religious concepts or constituent elements of what would become global modernity.[9] Without going afield in discussions about Aristotelian and biological kinds (When is a Baptist church no longer a Baptist church?), it is appropriate to ask whether all ideas spread in the way Dunch imagines. In particular, when ideas about the natural world move from one civilization to another, does their expression take a fundamentally new form?

However persuasive culture-relative commentary is for dealing with sophistical agency centering on allusion, prayer, and revealed truth that is, the legions of religious, political, and literary ambassadors--it seems inapplicable to rational agency based on quantification, observation, and demonstrationBnotably physicists and astronomers in the nineteenth and

twentieth centuries. Religious groups continually revise their affiliations and consanguinity as cultural variation provokes schism--the creation of another faith. Notable current instances include Catholic liberation theology in Latin America and the Episcopal ordination of homosexuals in the United States. Whereas medicine harbors astonishing variations in paradigm, even within one regime of heath care, differentiation within the exact sciences to the extent that it exists at all is of another kind. There have been no challenges to the periodical chart of the chemical elements or the laws of thermodynamics by physicists in Argentina or China; and although geocentrism continued to be taught in early twentieth-century Morocco and perhaps also in other settings like Indonesia, India, and New Mexico, astronomers in Texas or Tokyo have not recently challenged Copernicus. I have consistently argued that this feature of the exact sciences which might be called invariance--allows them to carry prestige and serve the imperial interest of metropolitan authorities.[10] If a precedent is required, then one may look to the way that Pericles justifies the empire of Athens, in part on Athenian art and philosophy: Taking everything together then, I declare that our city is an education to Greece.[11] Whether one likes it or not, quantum mechanics was forged and is now taught with tools developed for the most part in Western Europe. To the extent that fields of study like immunology and paleontology embrace the Baconian tools of mathematics and experiment, they too seem to be highly resistant to cultural variation.

Almost by definition, any notion of cultural imperialism revolves around apparently impractical goods and immaterial topoi, such as Jurassic botany or interstellar astronomy. If they are based on verifiable discourses (this leaves out spiritism and psychoanalysis, for example), we may imagine that other erudite enterprises carry cultural authority in the same way as physics. To see how this works, we have only to consider German historical practice in the nineteenth century and French historical practice in the twentieth century, for the immense prestige of those traditions has kept scholars in the United States arguably the largest community of practising historians from developing an independent historiography. The disturbing effects of a great historiographical tradition, the momentum carried by its concepts, the inertia of its prejudices these visible manifestations of cultural imperialism are what drew the attention of Edward Said in his essay of 1978 on Orientalism, where he laments a tradition of scholarship that, in his opinion, denigrates the Oriental, more particularly the Arab world.[12]

To a certain extent Edward Said did not write about historians *sui generis*, restricting his view largely to the English and French ambit. No one can study everything, and the focus is not unreasonable, but it should be

apparent that a look at literature written by German-speakers at the time of National Socialism, a regime that has provided the type specimen for policies of cultural and racial exclusivity is sufficient to raise questions about Said's thesis. Hermann Hesse and Elias Canetti received the Nobel Prize in Literature largely for novels about academics steeped in Oriental culture. The works have distinct tones: Hesse's protagonist Josef Knecht in *Das Glasperlenspiel* is treated sympathetically, while Canetti's protagonist Peter Kien in *Die Blendung* is a bitter satire. Both novels question the value of scholarship generally and the German research ethic in particular, but there is not a hint of caricature or patronizing about Chinese civilization.

The centerpiece of Said's thesis concerns how scholars for over three centuries systematically discounted the history and the integrity of Islamic civilizations. In his principal indictment, Edward Said tars Islamic scholars in Europe and North America with the brush of racism, in the view of two sympathetic critics condemning the entire field of study for its lack of humanity and dispassion on the one hand and on the other hand for inventing the notion of an Oriental spirit and then imposing it on conquered lands.[13] Said, however, is ambivalent about the value of *all* Orientalist scholarship. He writes:

What I am describing, then, is something that will characterize Islamic Orientalism until the present day: its retrogressive position when compared with the other human sciences (and even with the other branches of Orientalism), its general methodological and ideological backwardness, and its comparative insularity from developments both in the other humanities and in the real world of historical, economic, social, and political circumstances. The Orientalist believed that for the Oriental, liberation, self-expression, and self-enlargement were not the issues that they were for the Occidental. Instead, the Islamic Orientalist expressed his idea about Islam in such a way as to emphasize his, as well as putatively the Muslim's resistance to change, to mutual comprehension between East and West, to the development of men and women out of archaic, primitive classical institutions and into modernity.[14]

The Orientalist was racist.

Who was not racist one hundred years ago? Racism was a structural feature of European and North American civilization before 1914, and especially because of the association between race and nation (notably among French writers), few scholars whether philologist, historian, or chemist--had the presence of mind to reject it. A real question nevertheless remains: Does useful knowledge follow from the labor of Europeans writing about Islam and Asia, or should the enterprise be relegated to the domain of Mesmerism,

phrenology, and extra-sensory perception?

Enlightenment writers by no means minimized the accomplishments of the Islamic world in manufactures and works of art; for them, Islamic rule was no more authoritarian or whimsical than rule under the Old Regime in France. With the French Revolution came Modernity, symbolized by trousers and top-hats. Modernity helped define both Medievalism, for example, in the Gothic style of architecture and writing, and also Classicism, the veneration of Greek culture that found a name in Neohumanism. But these notions are the speculative fantasies of impractical people. The force of modernity came through the Industrial Revolution, which transmuted Enlightenment reason, clarity, and elegance into crude doctrines of material and social progress, finding issue in utilitarianism, positivism, social Darwinism, and pragmatism. With these doctrines came a discounting of civilizations beyond Europe at just the time that Europe devastated them.

Science and technology are independent and interacting enterprises, even though perceptions of the relationship between them varies over time. Although today technology dominates higher learning to the extent that science is now sometimes seen as an application of it, in the nineteenth century, science that which appeared as *Wissenschaft* in German universities was held to be anterior to technology; science, understood as a Baconian search for natural laws through experiment and mathematics, was widely seen as the key to material progress.[15] In part for this reason, civilizations were arranged on a phylogenetic tree according to their apprehension of science. By the end of the nineteenth century, the West was synonymous for the set of nations with a scientific outlook, those sitting at the highest part of the tree. From this point of view, much of the New World from Toronto to Mexico to Quito to Buenos Aires was Western; so was Japan. In all these settings, one surveyed earth and sky in comparable fashion; one used radiation and chemicals to probe the microscopic world; one generalized using algebra, statistics, and calculus.

The prosecution of science, late in the nineteenth century, became a justification for maintaining client civilizations. Scientific activity served as a territorial marker and as a universally recognized concomitant of the civilizing mission, for science was held to be accessible to all suitably prepared minds. In the Age of Imperialism, no other argument carried a transnational ring of authenticity. (The argument of proselytizers--Christianizing the world--is not really an argument at all, given the schisms in dogma among Christian churches.) Of course in the nineteenth century, conquest proceeded from swinishness the quickest route to riches is theft, whether of goods or labor and European élites robbed the world. Intellectuals, in their rôle as *chiens de basse cour,* scurried to justify their

privileged status, benefitting as they did from this savage exploitation. For them, superiority through science had a clearer ring than superiority through beauty or music or poetry. Telling the story of that superiority became the mission of historians of science at the dawn of the twentieth century.[16]

Several points require emphasis. First, that an idea is enlisted in the service of inhuman ends does not falsify the idea. The differential and integral calculus are not wrong because they are used in constructing intercontinental ballistic missiles, although the people who make the weapons are subject to our censure. Second, an idea is not wrong because a bad person proclaims it. That Charles Darwin was a racist is not a reason for rejecting natural selection. Finally, although I shall criticize the currently fashionable denial of the universality or truth of science, my argument about historians of science is able to encompass that pessimistic doctrine as well as Joseph Needham's metaphor of modern science as a great river fed by many tributaries flowing into the ocean of truth.

Just as all thinkers in medieval Christian Europe were not driven to inaction by religious dogma, so all nineteenth-century European scholars did not undervalue views of nature in eastern and southern civilizations. The present political conjuncture in Mesopotamia invites one example: Josef Epping's deciphering of cuneiform planetary ephemerides in nineteenth-century Quito, an accomplishment that led to the first reliable chronology of antiquity in the Mediterranean world.[17] Another example is the deciphering of Demotic and hieroglyphics. Later in the century came studies of antiquities at Angor Wat and Borobudur, among many others.[18] Elaborating monuments of the past contributes to the prestige of the elaborator, and recovering the past serves to include overseas territory into a particular cultural ambit, whether Dutch, German, French, or English. Yet to benefit the ends of empire, scholarship must nevertheless possess a general, transnational content; otherwise, it is perceived in its own time as nothing more than chauvinist rhetoric.

The contributions of scholars to English, French, German, Dutch, and Italian periodicals in the nineteenth century contain offensive characterizations of nations and cultures both within and beyond Europe. But it cannot be denied that among the contributions are many fair and reasoned analyses of Islamic, South Asian, and East Asian texts in science.[19] In fact, it is fair to say that knowledge among Europeans of medieval *European* science proceeded apace with knowledge about Islamic science. Late in the nineteenth century, there is a complementarity about the shortcomings of Pierre Duhem's research into science at medieval Paris and Marcellin Berthelot's studies of Islamic alchemy (it is relevant to observe that Duhem

was one of the most vociferous detractors of German learning during the First World War).

Why did the inspired fruit of isolated nineteenth-century efforts at fathoming Islamic science grow into a cornucopia of interest in Europe over the early decades of the twentieth century? In the spirit of the celebrated thesis of Eckart Kehr on national politics as the origin of international policy, it is reasonable to posit that early twentieth-century interest in Islamic science is an effect not of imperialist aggression in Africa and Asia but rather of general trends in higher learning, notably the dramatic expansion of universities and widespread adoption of the German research ethic. All manner of specialized inquiry received attention, from molecular physics (Albert Einstein's doctoral dissertation) to medieval romance (the doctoral dissertation of Einstein's sister Maria Winteler-Einstein). The burgeoning literature could barely be surveyed, much less controlled by academic cliques or learned societies. These circumstances alone suggest the limitations to a conspiracy of malevolence that governed Oriental studies.[20]

We are fortunate in having a record of the European study of Islamic science over the period when Edward Said claims scholarly Orientalism was at its height. It is found in the publications of George Sarton (1884-1956), the early twentieth-century promoter of history of science as a specialist discipline. For nearly 40 years Sarton edited the periodical *Isis*, to which he contributed some 10,000 bibliographical entries, sometimes with extensive commentary. The periodical furnished sources for his systematic introduction to the history of science, which he ended with the fourteenth century. Sarton was a scholarly generalist in a milieu that valued highly specialized research, but he learned enough Arabic to deal with primary and secondary material and to become the center of an international group dedicated to understanding science in medieval Islam. Historian of Islamic science Max Meyerhof, for example, writes from Cairo in 1927 to congratulate Sarton in English on the first volume of his *Introduction*, a wonderful, an astonishing creation! You did alone the work which in other comprehensive publications is done by a dozen of scientists, and you did it in the most competent manner. I am surprised to see how closely you followed p.e. the Oriental literature. There is nearly no matter of any importance omitted by you.[21] Twelve years later Meyerhof spoke for a dozen of his Arabist colleagues when he writes that Sarton is Ain nearly everything our spiritual leader.'[22] Sarton was not the foremost scholar in the group, but he was its buccinator. A review of his periodical and his writings reveals that Western historians of science labored to achieve a critical and balanced assessment of Islamic science over the first half of the twentieth century. Their work provided a model for Joseph Needham's extraordinary

survey of Chinese science. If, as one commentator has written, Needham is the modern Aristotle, Sarton's circle is the Academy.[23] Needham indeed deferred to his predecessor. He writes in 1954: An enquiry from Sarton takes VIP precedence over all other business.[24]

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George Sarton matured in his native city of Ghent just at the time that Belgium acquired a large portion of central Africa as a colony. If there is an example of science as a Trojan horse for political domination, then surely the Belgian Congo is paradigmatic, for the colony originated in the International Association for the Exploration and Civilization of Africa, called into being in 1876 by King Leopold II; if there is an example of science serving the needs of manufacturing, then it is surely August Kekulé von Stradonitz's arrival in 1858 to teach chemistry at Ghent, a center of the Flemish weaving and dyeing industry; and if there is an example of working-class socialism coupled with linguistic nationalism, then early twentieth-century Ghent is the place to find it. These currents, coupled with avant-garde Belgian Symbolist art and literature and art-nouveau interior design (for example, in the work of Victor *baron* Horta), all contributed to Sarton's outlook.[25]

Sarton's interest in things Oriental emerged in his early twenties. In his agenda on 4 May 1904 , he notes an article on Japanese painting, and he is the likely author of a poem in the same year about a Japanese legend recounting a woman who suffers the death of her lover.[26] In 1910, Sarton visited London and toured the exhibit of Japanese art at Shepherd's Bush. It nearly took me off my feet, he recalls late in life. He went to the Indian Museum in South Kensington; he met Arthur Henry Fox Strangways, an expert on Hindu music and art, and Ananda Kentish Coomaraswamy, a specialist of Hindu and Indonesian art who in 1917 became curator at the Boston Museum of Fine Arts. Both men, internationally recognized authorities on Oriental culture, contributed to Sarton's journal *Isis* and remained his friends to the end of their life.[27] Soon after his marriage, Sarton wrote in his diary on 1 September 1911 that he has decided to devote my life to the history of science. His light comes from the east: The Orient all intellectual manifestations of the Orient, art and science attract me. I feel that I am a bit Oriental. Perhaps I will study later the science of Egypt and Chaldea more closely.[28]

Among Sarton's earliest and strongest supporters was David Eugene Smith, historian of mathematics at Teachers College of Columbia University in New York. When Sarton was planning for the first number of *Isis*, Smith offered to provide an article on Japanese mathematics of the Seki school or on

indigenous Hindu geometry.[29] Smith volunteered to send out sample copies of *Isis* at his own expense, along with a covering letter of his own.[30] An early and enthusiastic supporter of *Isis* was also the Orientalist Paul Masson-Oursel, an expert on Buddhist thought.[31]

George Sarton was surely an idealist when in July 1914, oblivious of the impending war, he and his wife visited London. Motivating the visit was Sarton's fervent desire to learn more about South Asia. Sarton met again with Coomaraswamy. Sarton planned to devote no. 6 of *Isis* exclusively to science in India, and he prepared a review of a book by Coomaraswamy about Indian arts and artisans. The review, finally appearing in 1919, served to reprimand Western ignorance of Eastern civilizations its immense egoism. Indian art is situated at a pole removed from Western, individualistic art; but Indian crafts and decorative arts draw strength from the caste system, which keeps trades within families. Sarton drew lessons from Coomaraswamy, notably that a traditional genre of art contains the seeds of its own decline, for it has no strength to resist foreign corruption.[32] The war aborted Sarton's plans. Had it not intervened, it is possible that he would have devoted himself to Sanskrit and, perhaps, the art of South Asia, instead of to Arabic and Islamic science.[33] In London during July 1914, Sarton also visited the India Office, which convinces me that the English bureaucracy is not worth more than that of the Continent. The Office received all Hindu publications, but the people there could not be bothered to unwrap them quickly. The most recent volumes unwrapped were from 1911.[34]

Writing to his wife in 1915, Sarton reiterated his attraction to things Oriental and his desire to try his fortune in Japan after the war ends. He dreamed about training his daughter May in Japanese and Chinese and seeing her become a curator in a museum.[35] Sarton pursued the possibility of moving to the Orient with his family. He wrote to Nicholas Murray Butler of the Carnegie Endowment for International Peace and also to Robert S. Woodward of the Carnegie Institution, asking for a mission to East Asia to complete a general history of science.[36] London ceramist Harold Stabler, a friend of Sarton's wife Mabel who introduced Sarton to the Oriental ceramics of the Victoria and Albert Museum, encouraged Sarton's plans, offering that China is *the* place in the world.[37] In December 1915 Sarton asked Okuma Shigenobu, chancellor of Waseda University, about a trip to Japan.[38] He also enlisted the support of the former Belgian ambassador to China, E. de Cartier, for a position at the University of Peking, even though De Cartier advised against the initiative: The salaries were low, and life was both costly and dangerous.[39] As late as February 1918 Sarton considered traveling to Asia with his wife, a plan that the former Belgian ambassador to China continued to discourage.[40]

But Mabel Sarton welcomed plans for him to travel East. If offered a post that would not earn enough for me & [daughter] May to live on, he should *take it the same.*[41] Sarton abandoned the plan when he obtained continuing support from the Carnegie Institution of Washington. He nevertheless spent increasing amounts of time in the great Northeastern art museums studying Asian painting and sculpture.[42] By October 1922, Sarton realized that he could not hope to write his *History of Asiatic Art* until he had completed his *Introduction to the History of Science.*[43] He wanted to edit, nevertheless, a counterpart to *Isis* dealing with Asian art.[44]

Around 7 July 1915 George Sarton outlined his plans for the future. He must survive, and then he must secure *Isis*. He indicated the study of Oriental science and three other writing projects: Why I became a Buddhist, A Buddhist on the war, Buddhist art.[45] Sarton had been absorbing Buddhism for several years, largely in art but also in the writings of Moncure Daniel Conway, the pacifist in London whose lectures at the South Place Ethical Society were attended by Sarton's wife Mabel and her family. Sarton obtained Conway's book, *My Pilgrimage to the Wise Men of the East* (Boston, 1906), soon after he married Mabel, and he credited the book with awakening his interest in things Oriental.[46] Buddhist thought, with its emphasis on self-denial and introspection, appealed to him even more when, as a war refugee, he experienced material deprivation and scholarly stasis. We also read an affinity with Paul Carus, editor of the periodicals *Open Court* and *Monist* and a devotee of Buddhism, who published Sarton's early articles in the New World.[47]

When George Sarton started teaching at Harvard University in 1916, one of his first students was Yuen Ren Chao. Chao studied mathematics and philosophy at Cornell University and in 1914 was one of the organizers there of the influential journal *K'o Hseuh*, or *Science*, published in Shanghai, and with it the first scientific association in modern China, the Science Society.[48] Chao had already taken Lawrence J. Henderson's course in history of science, which consisted mainly in reading through John Theodore Merz's history of science in the nineteenth century, and he sought to make history of science one of his three fields for the doctorate.[49] Chao, who subsequently enjoyed a distinguished career at the University of California at Berkeley and at Tsinghua College in Beijing, became Sarton's first assistant.[50]

George Sarton depended on secondary works for his appreciation of science in Chinese history. As his introduction to the history of science reached the medieval period, he concludes in a sombre tone:

My main hobby (the study of ancient Chinese paintings) has inspired to me the deepest admiration for the Chinese people and, if I am prejudiced, it

is rather in their favor. But much as I love them, I am obliged to admit that they were great artists, that they showed considerable genius in practical affairs, for instance in the arts relative to printing or in husbandry, but that they were the weakest theoricians of all civilized peoples, ancient and modern. It is true that they did some very extraordinary work in mathematics, the formal nature of which appealed to them; their world-conceptions were not scientific in any sense, but an intolerable mixture of scholasticism and superstition.[51] Science, for Sarton, is about generalizing and moving on to new questions. In his own writings, he continually tried to extract provisional conclusionsBa synthetical inclination that brought only contempt from the great Orientalist Otto Neugebauer.[52] His characterization of science in China, which softened with the wisdom of age, might not be so far from the large distinction between the Mediterranean tradition of disputational theory and the East Asian tradition of irenic documentalism that attracted the eye of Nakayama Shigeru.[53]

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If George Sarton found his way to South Asia and East Asia through personal contacts, he acquired Arabic and a knowledge of Islamic civilizations by dint of private study and perseverance. His progress was slow and irregular. Arriving in Washington in 1915 as a refugee from Belgium, for example, he connected a past literary interest with a future scholarly focus on Arabic in the context of a technical invention. While I was reading the *Arabian Nights* after dinner, and while I was dreaming like one of [novelist] Francis Jammes' young creoles, I got at once the idea of a new kind of electric energy motor. (He drew up a prospectus, only to find that the motor had already been patented.)[54] Awaiting the birth of his third child in 1917, Sarton in New York writes to his wife in Cambridge that he is reading more of the *Arabian Nights* in the French translation of Joseph Charles Mardrus, far superior to [Sir Richard Francis] Burton's translation.[55] During the late 1910s, Sarton pursued an ambitious project to edit Leonardo's manuscripts; the project dissolved as he devoted himself to learning Arabic and compiling notes for a universal history of science.[56] Early in September 1920, the Sartons vacationed at Pemaquid Point, Maine, near the family of the Arabist from the Theological Seminary in Hartford, Duncan Black Macdonald; Macdonald became Sartron's first teacher of Arabic and a reviewer for *Isis*. Of his association with Sarton, Macdonald affirms: There is no part of my life as a scholar on which I look back with more satisfaction than this.[57]

As late as 1923 Sarton wrote that he has returned to studying Arabic by reading Sindbad the Sailor.[58] He emphasizes in 1924: Oriental, and

chiefly...Muslim science...are the largest terrae incognitae' in our maps of the development of human progress.[59] Sarton's commitment to Arabic was sealed when he planed for a sabbatical year in 1925. He wondered if his family should visit Italy in the summer. It might not be good for his daughter May, who still did not know French well, and it might be better for him to work on Arabic than on Italian. Italian is so easy that I can pick it up later in life. Arabic is so difficult that I must try to master it as promptly as possible. He asks if his wife would consider spending the summer in the foothills of the Atlas Mountains. For advice, he would write to geographer Emile Gautier, the funny old professor at the University of Algiers, who dined once or twice at our home. The great attraction of Algeria was the Sahara. He recalled painter and novelist Eugène Fromentin's enthusiastic & magnificent description of it, whether in his paintings or in his travel accounts.[60] Sarton's youthful *nom de plume*, which he used as late as 1912, is Dominique de Bray, borrowed from a novel of Fromentin's.[61]

Sarton writes in 1925: Our failure to appreciate properly Muslim science, involves a failure to understand mediaeval science as a whole.[62] The fruit of Sarton's study of Arabic is apparent in the first volume of his *Introduction to the History of Science*, appearing in 1927.[63] The volume extends to the year 1000 (CE). It sets out Sarton's view that science should be studied on a world scale, where contributions from all disciplines are considered synchronically. In a global perspective, the years 750 to 1000 constitute a golden age for science in Islam; the last three-eighths of the text divides entirely into titles bearing the name of an Islamic savant. Although much space in this and succeeding volumes is devoted to short summaries of significant thinkers and to sources for examining their work in greater detail (the *Dictionary of Scientific Biography*, ably edited by Charles Coulston Gillispie and Frederic Lawrence Holmes, is this approach writ large), the volumes are distinguished by synthetic chapter introductions, which generally focus on fifty-year intervals in the history of Eurasia. By 1925 Sarton is still reading Arabic extremely slowly, although his German colleagues Carl Schoy and Julius Ruska also did not read the language quickly.[64] In this race, the tortoises outstripped the hares.

Both the synthesis and the analytic summaries in the *Introduction to the History of Science* would have been impossible without *Isis*, whose name appears every few pages in the bibliographical notes. Sarton's journal was the research engine that powered his *Introduction*. The journal allowed him to receive review copies of significant monographs (and to benefit from expert appraisal of them), as well as to commission articles from international authorities. *Isis* placed Sarton in contact with thousands of scholars; he knew

the name and specialties of nearly every significant historian of science active between 1920 and 1950. Since he cast his net wide, he came into contact, in addition, with a broad range of humanists and scientists. From his mature years at Harvard University, students remember Sarton as an isolated figure.[65] By 1940, however, Sarton was 56 years old, and he had been urged by his physician to moderate his labor.[66] He knew the world through his voluminous correspondence, inevitably organized around *Isis*.

A look through the first ten volumes of *Isis* reveals unusual interest in Islamic science, by 1925 Sarton's principal focus of interest.[67] Frequent contributors were Carl Schoy, Julius Ruska, Duncan Black MacDonald, Charles Homer Haskins, Max Meyerhof, Eric John Holmyard, and Giuseppe Gabrieli; Sarton himself provided reviews of articles and books by Eilhard Wiedemann, Heinrich Suter, Henry George Farmer, and Thomas Francis Carter, among many other scholars. Sarton, while respectful of French-language literature, kept French commentary on Islam at arm's length. Indeed, some French writers do not hold up well in the pages of *Isis*: Holmyard's devastating critique of Marcellin Berthelot's work in the history of medieval Islamic chemistry is matched by Ruska's rejection of Maurice Maeterlinck's imaginary spirit of Islamic civilization.[68]

Severe criticism of what Edward Said might identify as Orientalist thought is visible in the pages of *Isis*. In 1923, Julius Ruska excoriates Oswald Spengler's *Untergang des Abendlandes*, a book distinguishing the Apollonian-Dionysian civilization of the Ancients and the Faustian civilization of the West from the magical civilization of Islam.[69] In his own writings, Ruska is wary about connecting a savant's environment with what appears from a savant's pen, although, in contrast to his judgment of Spengler, he nevertheless comments favorably on Carl Heinrich Becker's studies about Islamic civilization.[70] Sarton is more sympathetic to the life of savants than Ruska is, but Sarton also champions worldviews conceived beyond Europe. He quotes his faithful reviewer of South-Asian material, Paul Masson-Oursel:

> To us, the Orient teaches that our conceptual logic has a character that is exclusively European; that furthermore there has been the intelligible notion of intelligible relations other than the decomposition of a whole into its elements analysis or the composition of elements into a whole synthesis; that there have been theories of reasoning not founded on theories of judgment, and theories of judgment not founded on theories of the concept.[71]

The editor of *Isis*, indeed, is remarkably sympathetic to Oriental philosophies, even philosophies that challenge the bases of experimental and mathematical science. He is enthusiastic about Rabindranath Tagore's translation of mystical poems by Kabir.[72] His comments on a journal devoted to Ayurvedic

medicine might be nailed to the masthead of a postmodernist treatise: The Ayurveda movement is a revolt not only against the intellectual domination of an alien race, but also against the highly artificial tendencies of our age, a return to simpler and more natural life, diet and therapy.[73] Simply put, Sarton's understanding of knowledge past is incompatible with the doctrines of an unreconstructed positivist, as his allegiance has mistakenly been identified.[74]

Sarton's sense of Oriental science is given general expression in an essay, East and West, prepared as a Colver Lecture at Brown University in 1931, after he had worked through science in the early centuries of Islam. The almost unbelievable vigor of the new culture may be well measured by the international triumph of the Arabic language, he observes. It was an ecumenical setting for science, where savants of nearly all creeds and origins worked toward a common purpose. Much of their activity concerned rehabilitating Greek texts, but they did not simply transmit ancient knowledge, they created a new one. Sarton places the Islamic triumph in the context of his own time:

The superiority of Muslim culture, say in the eleventh century, was so great that we can understand their intellectual pride. It is easy to imagine their doctors speaking of the western barbarians almost in the same spirit as our do of the Orientals. If there had been some ferocious eugenists among the Muslims they might have suggested some means of breeding out all the western Christians and the Greeks because of their hopeless backwardness.

Sarton imagines that those among his contemporaries who condemn the East and lionize the West are lacking in an understanding of science, for in science Islam revealed its strength. He concludes:

The scientist who is not too proud, who does not assume an aggressively western attitude, but remembers the eastern origin of his highest thoughts, who is not ashamed of his ideas, will not be more efficient, he will be a more humane, a better servant of the truth, a better instrument of destiny, a gentler man.[75]

Sarton is a balanced commentator on Islamic civilization, notably with regard to religious fundamentalism in it. He is a stern critic of scholasticism, an appeal on the basis of faith to canonical texts, which he identifies at the root of medieval thought in many civilizations: We can witness the desperate efforts of a large number of Muslim, Jewish, and Christian schoolmen to reconcile Hellenic rationalism with three different sets of religious dogmas. What is most extraordinary is that they all succeeded in doing this to their satisfaction. In his view, progress depends particularly upon the emancipation of science from religion, an emancipation accomplished after the sixteenth century much

more effectively in Western Europe than in Eastern civilizations.[76]

Some of Sarton's correspondents were circumspect about Islamic cultures. Max Meyerhof, a practising opthamalogist in Cairo, was inelegant about the commitment of Egyptians to purchasing a volume of Sarton's: There is the thing which disgusted so much my dear friend [Henri] Grégoire, that Orientals nearly never keep their promises and engagements; it is possible to deal with them only in handling them like children![77] (In 1926 Grégoire became dean of the Faculty of Letters at the renovated Egyptian University in Cairo.[78]) Meyerhof, facing Nazi criminality, dwelt on brigandage in Palestine: The Turks eradicated these bad habits by freely hanging, the only effective treatment of three thousand year old robbery-instincts.[79] Generally Meyerhof saw the matter in terms of practical needs. He wrote in English in 1922: The Egyptians themselves as most of the young nations do not show much interest for the scientific history of their own ancestors, as far as it does not satisfy their national prand [*sic*]. Nevertheless I hope that the new spirit will come more and more![80]

There can be no doubt, nevertheless, that Sarton's circle was tolerant of Mediterranean and Asian civilizations in a way that escaped other academic writers of the time, from social darwinians and eugenicists to a wide range of anthropologists. In fact, from the very beginning of his periodical *Isis*, Sarton was unable to attract patrons and contributors troubled by his ecumenical orientation.[81] We obtain a clear sense of Sartonian equanimity in a letter in English from Meyerhof to Sarton, where Meyerhof contrasts backward Germany to progressive Egypt:

I have been elected as a member of the Institut d'Egypte and will try to help to the awakening of this sleeping academy'. On the other hand, [Karl] Sudhoff asked me whether I was envious to accept the Leipzig professorship for History of Medicine in the case [Henry] Sigerist would accept the nomination to the Johns Hopkins chair which had been offered to him. The hope to be entitled to a pension in case of incapacity to work would be the attraction of such an offer, besides the wonderful Leipzig Institute and Library. But the actual state of things in Germany and the prevalence of intolerance and racial nationalism in German universities would alone prevent me from accepting the offer. After the free field of international relations here I could not live behind the barbed wire of stupid prejudice.[82]

And Meyerhof was not alone among Sarton's correspondents in rejecting nationalism. George Sarton's faithful reviewer and correspondent Paul Masson-Oursel observed about a work on Hindu physics by the Indian nationalist Kishori Lal Sirkar:

It is the exposition of atomistic physics implied in one of the 6 orthodox

systems: Vaisesika. The fault seems to me to consist with most natives who have a nodding acquaintance with European science, be it only with its most elementary vocabulary, for on a whim they claim to find in their very old texts the essential parts of European ideas. In this way, they risk understanding neither our science nor their own past.[83]

Edward Said represents Masson-Oursel as an imperialist exploiter of the Orient, but in fact Masson-Oursel was a syncretist who wrote enthusiastically upon the foundation of *Isis* that Sarton's orientation fit well with his own training under Emile Durkheim and Gaston Milhaud and his own fervor for comparative philosophy in the service of historical synthesis.[84] Equanimity extends to Duncan Black Macdonald, identified by Edward Said as a mean Orientalist ignorant of the achievements of Islamic science, who knows how to discount the prejudices in an anthropological commentary on Arab life.[85] And consider the influential scholar Sir Hamilton Alexander Roskeen Gibb, whom Said represents as a systematic denigrator of Islamic civilizations. Gibb writes to George Sarton in 1947:

You are in many respects more in touch with men & ideas on the Continent of Europe than we are, but I am sometimes disturbed by the lack of any sense of urgency amongst people here. Perhaps they are right & there is no urgency, but I cant help feeling that we should be doing more than we are doing to rebuild & [reform?] the cultural life of Europe. Or are we obsessed by the thought that for every bridge we try to build the scientists are preparing to blow up a thousand?

I don't really think so. The trouble seems rather to be that no real or close association is quite painless, & every one on every side shrinks from the sacrifices it demands not the material ones if there are any, but the spiritual ones, the breaking down of our isolations or self-sufficiencies. We want to show the world that British or American or French, or Cscience, or learning, or art or what-not still stands at the top of the list. And the governments are doing their best to hinder mutual help by restrictions on the transfer of books & every form of international intercourse.

But I am becoming violent or bitter and I have least excuse of anybody for bitterness. No memories could be happier than those of the friendly meetings & talks that I enjoyed during these recent visits to America, & my relations with all our French or other European colleagues are extremely cordial You by just being where you are in Harvard & maintaining your network of correspondence are doing as much as any man, I think, to keep us all together. If ever there were an honorary citizenship of the world, you should be citizen no. 1! And what could not Oxford & Harvard & Paris do to make a common citizenship in letters at least, a reality.[86]

The condescension of a don, certainly, but an expression of ecumenism is unmistakable at precisely the time when, in some parts of the Islamic world, ecumenism was in short supply.

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George Sarton recognized early in 1920 that his exhaustive project (the description is Joseph Needham's)[87] required his permanent installation in Harvard's new Widener Library. Located with his family in miserable accommodations in Washington, just having returned from four months of travel in Europe, Sarton wrote: I am dreaming of going back to Cambridge; this seems to me now to be [the] only place in this country where there is a sufficient depth & a sufficient density of culture to make life bearable.[88] He persuaded his employer, the Carnegie Institution of Washington, of the scheme, and his patron Lawrence J. Henderson at Harvard arranged for him to be appointed lecturer at no salary, giving a few lectures in the course of the year in payment for the use of a room in the library.[89] Sarton explained his flight from Washington in a letter to Antonio Favaro. In addition to difficulties with continuing *Isis*, the intellectual atmosphere of Washington does not please me: Life is too political, too bureaucratic, with too much wealth and too little culture. He will move to Cambridge, the most civilized city in America.[90] Sarton came to resent his marginal status at Harvard (eventually regularized by a professorship), but Widener received only his laudation.[91]

When Joseph Needham conceived his own narrative account of science and civilization in China, he was the Sir William Dunn Reader in Biochemistry at the University of Cambridge, although by the time that his first volume appeared in 1954 he had become Master of Gonville and Caius College. Cambridge, the ranking scientific university of England, was the appropriate setting for his undertaking. In launching his work, Needham (generous by nature) begged Sarton's indulgence:

His great and indispensable work will always fulfil the role of a mine of suggestions for research, as well as of an encyclopaedia of information; and it is to be hoped that no one would feel (as I am sure that he himself would not) that so great an achievement would render unnecessary the elaboration of monographs such as the present one.[92]

Sarton figures throughout early volumes as an authority, both for his historical discoveries and his interpretations.

Among scholars in the middle of the twentieth century, it would be hard to find a thinker more independent than Joseph Needham. He was sympathetic to religion while remaining a firm defender of the Soviet Union.

Holder of high office in London and Cambridge, he was generous about crediting remotely-situated colleagues. Just as George Sarton does not receive good press today, it has become fashionable to discredit Needham's view of history of science, in which different civilizations retain the honor of discoveries while nevertheless privileging the formulation of scientific method in Western Europe.[93] Yet at the present time, when competing social groups seek to exterminate rivals with depressing regularity, it is refreshing to revisit the ecumenism of Joseph Needham and George Sarton, which found expression in the search for a master narrative about science.

I suspect that, notwithstanding his condemnation of canonical interpretations of history, Edward Said would not have found Needham and Sarton unsympathetic. Said concludes *Orientalism* with a Sartonian plea:

If we remember that the study of human experience usually has an ethical, to say nothing of a political, consequence in either the best or worst sense, we will not be indifferent to what we do as scholars. And what better norm for the scholar than human freedom and knowledge? Perhaps too we should remember that the study of man in society is based on concrete human history and experience, not on donnish abstractions, or on obscure laws or arbitrary systems.[94]

Great Marxist scholars of the last century like Needham, Dirk Struik, and Antonie Pannekoek certainly were not shy about engaging in politics, but who among historians of science was more passionate about freedom and knowledge than social-democrat George Sarton?

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Edward Said's thesis that knowledge about the world is segregated according to the culture of the knower finds a counterpart in the postmodernist contention that modern science is nothing more than local knowledge; postmodernist historians of science share the indifference of Sherlock Holmes and Dante Gabriel Rossetti about whether the earth lies at the center of the universe. Professions of the postmodernist faith that knowledge is a relativist, social construction are still commonplace. A prominent geographer at the University of Edinburgh, Charles W. J. Withers, affirms that maps do not mirror reality so much as they reveal their makers: Maps do not reflect what there is so much as they reflect the concerns of their makers.@ Notwithstanding his rhetorical plea for contextualizing cartography, however, Withers does not deny that there is a truth, for example, to the course of the Niger River in Africa and that the place of the river may be known with certainty from accurate maps.[95] In a recent survey of cultural imperialism, sociologist Bernd Hamm, who is Jean Monnet Professor of European Studies

and UNESCO Chair in Europe in a Global Perspective at the University of Trier, contends that science is a doctrine serving to keep the world in chains: Western concepts of science and truth are used to legitimate interests aimed at the suppression and exploitation of nature and humans. They are used to mask the destructive character of Western political-economic interests. In doing this, science and truth have become ideologies. As such, they tend to benefit the 'Power Elites' (C.W. Mills 1956) of society and, of course, the scientific community, at the cost of the population at large. The forced global imposition of this understanding of science and truth is part of cultural imperialism.

Hamm proposes that science is just one of many codes for acquiring knowledge, and irrelevant as this code might be for the majority of ordinary people, it has still succeeded in gaining strategic influence among cadres.[96] But Hamm is a soft-core critic of science, for he does not maintain that scientific medicine is as effective in curing disease as voodoo, that Maxwell's equations are no more certain guides to nature than the residues of tea leaves are, and that polymers can be synthesized as effectively through prayer as by way of chemistry.

Reading Withers's and Hamm's work, I sense a defensiveness that was absent a decade ago among writers sympathetic to postmodernist doctrine. If their writing is a guide, then there has been a generally favorable reception to recent surveys about imperialism and world-wide science emphasizing the essential unity of certain learned disciplinesBgeology, and astronomy, and history--in the modern period.[97] That is to say, evidence reveals categories of analysis that transcend the particular setting of someone who engages them; people everywhere, in sum, may discover regularities of nature.

In a rebuke of postmodernist relativists that may also caution uncritical admirers of Edward Said's writings, Michael Hardt and Antonio Negri, writers who are stern critics of Western domination--emphasize:

The postmodernist epistemological challenge to the Enlightenment' its attack on master narratives and its critique of truth ...loses its liberatory aura when transposed outside the elite intellectual strata of Europe and North America. Consider, for example, the mandate of the Truth Commission formed at the end of the civil war in El Salvador, or the similar institutions that have been established in the post-dictatorial and post-authoritarian regimes of Latin America and South Africa. In the context of state terror and mystification, clinging to the primacy of the concept of truth can be a powerful and necessary form of resistance. Establishing and making public the truth of the recent past attributing responsibility to state officials for specific acts and in some cases exacting retributionBappears here as the ineluctable precondition for any

democratic future. The master narratives of the Enlightenment do not seem particularly repressive here, and the concept of truth is not fluid or unstable on the contrary![98]

It is possible to connect this view with the thought of Noam Chomsky, a linguist whose consistent and reasoned criticism of imperialism is a matter of record. Chomsky writes:

Many scientists, not too long ago, took an active part in the lively working class culture of the day, seeking to compensate for the class character of the cultural institutions through programs of workers' education, or by writing books on mathematics, science, and other topics for the general public. Nor have left intellectuals been alone in such work, by any means. It strikes me as remarkable that their left counterparts today should seek to deprive oppressed people not only of the joys of understanding and insight, but also of tools of emancipation, informing us that the project of the Enlightenment is dead, that we must abandon the illusions of science and rationality, a message that will gladden the hearts of the powerful, delighted to monopolize these instruments for their own use.[99]

Noam Chomsky writes as the social conscience of modern science. In its veneration of utility, however, the Enlightenment contains the seeds of both the prosecution and the erosion of science. In the decade since Chomsky set down the foregoing lines, science has increasingly become driven by technological imperatives. Although abstract, speculative endeavors in the past have often been sustained only with great difficulty, today *science* as the word has been understood over the past two centuries is threatened with eclipse by demands for pecuniary gain.[100] If the coming period in the West turns out to resemble the Roman or the Ottoman empire, followers of Edward Said might anticipate witnessing the attenuation of active, dispassionate investigation into the regularities of the natural world.

That would belong to the past. The future is captured in a recent observation by the British historian of design Lanto Synge, who sees signs that A new style, neither brutal nor twee, will help restore self-confidence and interest in the wake of post-modernism.'[101] It is a future outlined a generation ago by critic George Steiner, whose thoughts appeared at the beginning of my story. Steiner, at the end of his essay *In Bluebeard's Castle*, reconsiders Max Horkheimer and Theodor W. Adorno's contention, in their *Dialektik der Aufklärung*, that the old obscurantisms of religious dogma and social caste have been replaced by the even more tyrannical obscurantism of rational, scientific truth. Nowhere do Horkheimer and Adorno provide a template for a mode of human perception freed from the 'fetishism of abstract truth.' In Steiner's view, The pursuit of the facts, of which the sciences merely provide

the most visible, organized instance, is no contingent error embarked on by Western man at some moment of élitist or bourgeois rapacity. Rather, it is hardwired into the human brain, in the manner of Chomsky's fundamental syntax. Steiner, the polyglot reader of comparative literature, is uncertain where reason shall lead, but he is unambiguous about the importance of history of science in forging the path forward: The absence of the history of science and technology from the school syllabus is a scandal. He is clear, too, about the centrality of the author of *Science and Civilization in China.* For Steiner, Proust's only successor is Joseph Needham.[102] Can it not be, then, that the new style intimated by Lanto Synge is the one stemming from Needham's enlightened prose and comparative spirit? However we understand culture over the coming years, the understanding will be informed by direct contact with the thought of peoples located at all points of the compass. That we know each other's meaning, even if incompletely and imperfectly, vindicates the enterprise of the ecumenical historians of science in George Sarton's orbit during the early twentieth-century Golden Age of learning.

Notes

1.George Steiner, *In Bluebeard's Castle: Some Notes towards the Redefinition of Culture* (New Haven, 1971), pp. 3-4, 7.

2.Walter Benjamin, Theses on the Philosophy of History, in *Illuminations,* trans. Harry Zohn (New York, 1968), pp. 259-60 (Thesis IX). It is an image that Benjamin elaborated in the 1930s, as Hannah Arendt observes in the book's introduction. Benjamin introduces the thesis with a quatrain by Gerhard Scholem. Zohn's translation of Scholem's poem makes no sense to me, providing timeless time for lebendige Zeit. I prefer: My wing is ready to soar,/I would rather turn back,/If I stayed with unfolding time,/ I would have little luck. Marion Kintzinger, Der Engel der Geschichte: Gestaltungsformen historischen Denkens in der frühen Neuzeit und bei Walter Benjamin, *Archiv für Kulturgeschichte, 81* (1999), 149-72, for a comprehensive survey of writing about Benjamin's angel; Philippe Fleury, L'Ange comme figure messianique dans la philosophie d'histoire de Walter Benjamin, *Archives de sciences sociales des religions, 78* (1992), 169-77, for a discussion of Benjamin's sources and inspiration; O. K. Werckmeister, Walter Benjamin, Paul Klee, and the Angel of History, *Oppositions, 25* (1982), 102-25, for the evolution of Benjamin's ideas about history and destruction. Benjamin's angel has been enlisted to serve many masters. Judith Perkins, The Angel of History, *Classical World, 96* (2003), 421-6, for the angel as a harbinger of

postmodern relativism. I elaborate in a forthcoming publication, Forward into the Past.

3.Jürgen Habermas, *The Philosophical Discourse of Modernity*, trans. Frederick G. Lawrence (Cambridge, Mass., 1990), pp. 14-15 for the analysis of Walter Benjamin.

4.Steiner, *Bluebeard's Castle*, pp. 8, 133-5. It is possible that Steiner's entirely optimistic vision of the history of science is due in part to conversations with his Yale University colleague Derek J. de Solla Price, a promoter of the humanities of science and a founder of the field of scientometrics.

5.Gunther Stent, *The Coming of the Golden Age: A View of the End of Progress* (Garden City, N.Y., 1969). The work has been popularized by John Horgan in his claim that science has gone as far as it can go: *The End of Science: Facing the Limits of Knowledge in the Twilight of the Scientific Age* (Reading, Mass., 1996), pp. 9-16.

6.John Ralston Saul, *Voltaire's Bastards: The Dictatorship of Reason in the West* (New York, 1993), pp. 584-5; Václav Havel, *Disturbing the Peace: A conversation with Karel Hvíala*, trans. Paul Wilson (New York, 1991), pp. 13-15.

7.For many years I had in my office a collection of about 12,000 German doctoral dissertations from the years 1895-1925; in the 1990s, the bulk of the collection went to the library of Université de Montréal. Acquired by the University of Pennsylvania through exchange agreements, the dissertations spanned all faculties and most German-language universities; following their deaccession, the dissertations were given to me by librarian Rudolf Hirsch. Lewis Pyenson, The Liberation of Higher Learning, Council of Graduate Schools (Washington), *Communicator, 21,* no. 4 (1998), 1-4; Lewis Pyenson and Douglas Skopp, Educating Physicists in Germany *circa* 1900, *Social Studies of Science, 7* (1977), 329-66.

8.Arnold J. Toynbee, *A Study of History, Volume 9* (London, 1954), pp. 705-17.

9.Ryan Dunch, Beyond Cultural Imperialism: Cultural Theory, Christian Missions, and Global Modernity, *History and Theory, 41* (2002), 301-25, on pp. 318, 324.

10.Lewis Pyenson, History of Science in History, in *Science, Technology, and Society*, ed. Sal Restivo, (New York,2005), pp. 188-95.

11.Thucydides, *History of the Peloponnesian War*, trans. Rex Warner (1954; New York, 1972), p. 147.

12.Edward Said, *Orientalism* (1978; New York, 1994).

13.Michael Hardt and Antonio Negri, *Empire* (Cambridge, Mass., 2000), p. 125.

14.Said, *Orientalism*, pp. 261, 263.

15.Lewis Pyenson and Susan Sheets-Pyenson, *Servants of Nature: A History of Scientific Institutions, Enterprises, and Sensibilities* (London, 1999), p. 438.

16.Lewis Pyenson, Prerogatives of European Intellect: Historians of Science and the Promotion of Western Civilization, *History of Science, 31* (1993), 289-315; The Ideology of Western Rationality: History of Science and the European Civilizing Mission, *Science and Education, 2* (1993), 329-43.

17.Lewis Pyenson, *Civilizing Mission: Exact Sciences and French Overseas Expansion, 1830-1940* (Baltimore, 1993), pp. 312-13.

18.Lewis Pyenson, Assimilation and Innovation in Indonesian Science, *Osiris, 13* (1998), 34-47.

19.The extent of their scholarship is revealed in François Charette's remarkable thesis, *Orientalisme et histoire des sciences: l'historiographie européenne des sciences islamiques et hindoues, 1784-1900* (MSc thesis, Université de Montréal, 1995).

20.There is a large literature commenting on Edward Said's *Orientalism*. Noteworthy are Keith Windschuttle's analysis of Said's use of British novels, Cultural History and Western Imperialism: The Case of Edward Said, *Journal of the Historical Society, 1,* nos 2/3 (2000), 169-206; Peter Heehs, Shades of Orientalism: Paradoxes and Problems in Indian Historiography, *History and Theory, 42* (2003), 169-95, pp. 170-2 for criticism of Said and a taxonomy of scholarship about South Asia; and John M. MacKenzie, *Orientalism: History, Theory and the Arts* (Manchester, 1995).

21.George Sarton Papers: bMS Am 1803.1 (letters by George Sarton), bMS Am 1803.2 (letters to George Sarton), Houghton Library of Harvard College Library, Cambridge, MA [henceforth HGS], Max Meyerhof to George Sarton, 23

September 1927.

22.Thomas F. Glick, From the Sarton Papers: Paul Kraus and Arabic Alchemy, *Cronos, 2* (1999), 221-44, on p. 240.

23.Mansel Davies, Joseph Needham (1900-95), *British Journal for the History of Science, 30* (1997), 95-100.

24.HGS, Joseph Needham to George Sarton, 27 September 1954.

25.The issues are treated in my forthcoming book, *The Passion of George Sarton: A Modern Marriage and Its Discipline.*

26.Charles Holme, Japanese Flower Painting, *The Studio*, 15 April 1904; G. S., O'Kama d'Osaka, *Almanach de l'Université de Gand* [Société générale (fédération) des Etudiants libéraux], 1904, pp. 378-9.

27.George Sarton, Why *Isis*? *Isis, 44* (1953), 232-42, on p. 235 for the Japanese exhibition, Fox Strangways, and Coomaraswamy. James S. Crouch, *A Bibliography of Ananda Kentish Coomaraswamy* (New Delhi, 2002), for commentary on Coomaraswamy's enormous *oeuvre;* Roger Lipsey, *Coomaraswamy: His Life and Work* (Princeton, 1977), p. 91 for the India Society and the musical connection. Coomaraswamy was the son of a Tamil father and English mother; he was the first director of the Geological Survey of Ceylon. By the eve of the First World War, he had become an Indian nationalist and his interest turned toward Indian philosophy and art, which he collected. A. H. Fox Strangways, *Music and Letters, 29* (1948), 229-37, for a number of appreciations in the journal that he founded. On Shepherd's Bush: Ayako Hotta-Lister, *The Japan-British Exhibition of 1910: Gateway to the Island Empire of the East* (Richmond, Surrey, 1999).

28.George Sarton's diaries: MS Am 2117, *60M-177. Houghton Library of the Harvard College Library, Cambridge, MA [henceforth Diary], 1 September 1911.

29.HGS, David Eugene Smith to George Sarton, 25 October 1912. Probably Smith means Seki Takakazu, a key figure in the formulation of the Japanese style of mathematics known as *wasan.* Seki and *wasan* are treated by Smith in *A History of Japanese Mathematics* (Chicago, 1914). Smith's close colleague was Mikami Yoshio, also later a correspondent of Sarton's.

30.HGS, David Eugene Smith to George Sarton, 14 November 1912.

31.HGS, Paul Masson-Oursel to George Sarton, 4 January 1913 and 23 January 1913.

32.George Sarton, Ananda K. Coomaraswamy, *The Arts and Crafts of India and Ceylon*, *Isis, 2* (1919), 404-7.

33.George Sarton, Why *Isis*? *Isis, 44* (1953), 232-42, on p. 242.

34.George Sarton to Mabel Sarton, 10 June 1915, Correspondence between George Sarton and Eleanor Mabel Sarton, The Berg Collection of English and American Literature, The New York Public Library, Astor, Lenox and Tilden Foundations, New York, George Sarton to Mabel Sarton, 14 July 1914. Subsequent letters between George and Mabel Sarton come from the New York Public Library.

35.George Sarton to Mabel Sarton, 10 June 1915.

36.Diary, 6 October 1915; Archives of the Carnegie Institution of Washington, Washington, DC, George Sarton to Robert S. Woodward, 6 October 1915.

37.HGS, Harold Stabler to George Sarton, 29 April 1915. Sarton recalls the tour of Oriental ceramics on 7 March 1915 in a memorandum located in the George Sarton papers, consulted at the residence of May Sarton, York, Maine [henceforth YMS]. Since 1997 the material has been dispersed, much of it to the Berg Collection at the New York Public Library.

38.Diary, 3 December 1915.

39.HGS, E. de Cartier to George Sarton, 23 December 1915 and 11 May 1916.

40.Mabel Sarton to George Sarton, February 1918.

41.Mabel Sarton to George Sarton, received on 18 February 1918.

42.George Sarton, Matériaux pour l'histoire de l'art asiatique (première série), *Gazette des beaux-arts, 8* (1923), 1-17; George Sarton, Art as an Approach to Asia, *Yale Review, 15* (1926), 540-52, on pp. 540, 551-2.

43.Diary, 1 October 1922.

44.George Sarton, Why Isis? *Isis, 44* (1953), 232-42, on p. 236.

45.Located in the Papers of May Sarton, Series XV Family Papers 1846-1993, Boxes 171-182, The Berg Collection of English and American Literature, The New York Public Library, Astor, Lenox and Tilden Foundations, New York [henceforth NYPL].

46.George Sarton, Adventures of a Scholar's Wife, notes for a biography of Mabel Elwes Sarton, in NYPL. In 1914 Sarton notes a biography of Conway, the general thinker and noble pilgrim. George Sarton, John M. Robertson, *The Life Pilgrimage of Moncure Daniel Conway, Isis, 2* (1919), 450.

47.George Sarton, The Future of Belgium, *Open Court, 29* (1915), 257-72; George Sarton, The History of Science, *Monist, 26* (1916), 321-63. The *Open Court* article was a collaboration with Mabel Sarton. Pyenson, *Passion of George Sarton.*

48.Yuen Ren Chao, *Life with Chaos: The Autobiography of a Chinese Family, 2: Yuen Ren Chao's Autobiography, First 30 Years, 1892-1921* (Ithaca, 1975), pp. 79, 84. Zuoyue Wang, Saving China through Science: The Science Society of China, Scientific Nationalism, and Civil Society in Republican China, *Osiris, 17* (2002), 291-322, on p. 304. In Pinyin, Chao's name is given as Zhao Yuanren.

49.HGS, Yuen Ren Chao to George Sarton, 30 June 1916.

50.George Sarton to Mabel Sarton, 8 March 1925, for recruiting a successor to Chao. George Sarton, *Introduction to the History of Science, Volume 1: From Homer to Omar Khayyam* (Baltimore, 1927), p. 48, for Chao's earlier labor as an assistant.

51.George Sarton, Alfred Forke, *The World-Conception of the Chinese, Isis, 7* (1925), 373-5.

52.Lewis Pyenson, Inventory as a Route to Understanding: Sarton, Neugebauer, and Sources, *History of Science, 33* (1995), 253-82, on pp. 274, 282 (note 106).

53.Shigeru Nakayama, *Academic and Scientific Traditions in China, Japan, and*

the West, trans. Jerry Dusenbery (Tokyo, 1984), pp. 3-16.

54.George Sarton to Mabel Sarton, 26 and 27 April 1915. George drew up a prospectus on 25 April 1915, corrected it on 27 April. YMS, for the correction on 27 April 1915.

55.George Sarton to Mabel Sarton, 27 July 1917.

56.As he describes in George Sarton, *Six Wings: Men of Science in the Renaissance* (Bloomington, 1957), p. 306. Francis Jammes, a French Catholic novelist, was one of young George Sarton's favorite writers.

57.As Sarton relates in *Introduction to the History of Science, Volume I*, p. 45, and Why *Isis*? *Isis, 44* (1953), 232-42, on p. 237. Sarton has Macdonald vet his comments on publishing Arabic words in the Roman alphabet. George Sarton, Note on the Transliteration of Arabic, *Isis, 6* (1924), 410-12, on p. 412. Macdonald in William Douglas Mackenzie, Duncan Black Macdonald, Scholar, Teacher, and Author, in *The Macdonald Presentation Volume*, ed. Robbins Wolcott Barstow (Princeton, 1933), pp. 1-9, on p. 6. Thomas F. Glick, trans. Mercè Viladrich, *George Sarton i la història de la ciència a Espanya* (Barcelona, 1990), p. 19.

58.George Sarton to Mabel Sarton, 5 August 1923.

59.George Sarton, Introduction to the History and Philosophy of Science, *Isis, 6* (1924), 543-6, on p. 546.

60.George Sarton to Mabel Sarton, 25 January 1925. Emile Gautier was a stern critic of the notion of African cultural clusters developed by German ethnologist Leo Frobenius. George Sarton, *Isis, 4* (1921-22), 623.

61.Dominique de Bray, pseud. George Sarton, Romain Rolland et Malwida von Meysenbug, *Flamberge,* no. 11 (1913), 503-9, Sarton's article dated November 1912. The issue is devoted to Romain Rolland. A copy of this issue is available in the Bibliothèque Nationale de France (Tolbiac, Rez-de-jardin), Paris. For Rolland's reaction: Romain Rolland to Jean-Richard Bloch, 17 December 1913, in *Deux hommes se rencontrent: Correspondance entre Jean-Richard Bloch et Romain Rolland (1910-1918),* ed. Mme Jean-Richard Bloch and Mme Romain Rolland [Cahiers Romain Rolland, 15] (Paris, 1964), p. 223. Marie-Brunette Spire kindly alerted me to this passage.

62.George Sarton, reviewing E. J. Holmyard's edition of a work by Abu'l-Qâsım Muhammmad ibn Ahmad al->Irâqî, in *Isis, 7* (1925), 124-8.

63.George Sarton, *Introduction to the History of Science, Volume 1.*

64.HGS, Heinrich Wieleitner to George Sarton, 9 February 1925, for the quotation from a letter of Sarton's and for the comparison with German colleagues. Max Meyerhof to George Sarton, 6 November 1931, where Meyerhof comments that he and Joseph Schacht have to call for the help of a specialist in poetry in Arabic.

65.Henry Guerlac (who took a doctorate at Harvard University and knew Sarton there) comments that Sarton's contacts...with Harvard scientists seem to have been virtually non-existent. Guerlac, Sartoniana and Forward, *Lychnos*, 1986, pp. 1-27, on p. 9. Sarton's doctoral student I. Bernard Cohen recalls: Sarton was a lonely man. He had no colleagues at Harvard, very few close intellectual friends. I. Bernard Cohen, Introduction: The Impact of the Merton Thesis, in *Puritanism and the Rise of Modern Science: The Merton Thesis*, ed. Cohen (New Brunswick, N.J., 1990), pp. 1-111, on p. 26.

66.NYPL, Mabel Sarton to Marthe Patyn, 15 December 1935, in French, where Mabel observes that George is sometimes tired. He follows the advice of the doctor carefully since the *accroc* he had 3 years ago.

67.George Sarton to Mabel Sarton, 15 March 1925, where he comments that he is revising the Greek material in the first part of his *Introduction,* which he has completed.

68.E. L. Holmyard, A Critical Examination of Berthelot's Work upon Arabic Chemistry, *Isis, 6* (1924), 479-99, p. 485: I feel that it is quite unsafe to accept any of his conclusions without first referring to the original sources or without strong collateral evidence. Julius Ruska, Maurice Maeterlinck, *Das grosse Rätsel* [German translation], *Isis, 7* (1925), 167-8.

69.Julius Ruska, Oswald Spengler, *Der Untergang des Abendlandes, Isis, 5* (1923), 176-81. HGS, Julius Ruska to George Sarton, 31 January 1921, for Spengler's often fanciful assertions.

70 .Ruska's general strictures in his review of Carl Heinrich Becker's *Islamstudien,* in *Isis, 6* (1924), 559-61, a book that he finds appealing and useful.

71.George Sarton, Paul Masson-Oursel, *La Philosophie comparée, Isis, 6* (1924), 99-104, on p. 103.

72.George Sarton, Kabir, *One Hundred Poems, Isis, 3* (1920-21), 101.

73.George Sarton, *Journal of Ayurveda, Isis, 9* (1927-28), 555.

74.Tore Frängsmyr, Science or History: George Sarton and the Positivist Tradition in the History of Science, *Lychnos*, 1973/74, pp. 104-44.

75.George Sarton, East and West, in *The History of Science and the New Humanism* (New York, 1956), pp. 59-110, quotations on pp. 86, 89, 110.

76.Sarton, *Introduction to the History of Science, Volume 1*, pp. 27-9.

77.HGS, Max Meyerhof to George Sarton, 26 June 1931.

78.HGS, Max Meyerhof to George Sarton, 17 August 1926.

79.HGS, Max Meyerhof to George Sarton, received 21 January 1937.

80.HGS, Max Meyerhof to George Sarton, 5 September 1922.

81.The Ghent mathematician and historian of mathematics Paul Mansion as well as the French polymath Pierre Duhem both declined Sarton's invitation to sit on the first editorial board of *Isis;* they cited differences in approaching scholarship. HGS, Pierre Duhem to George Sarton, 11 April 1912, printed in George Sarton, Acta atque Agenda, *Archives internationales d'histoire des sciences, 4* (1951), 323-56, p. 354. HGS, Paul Mansion to George Sarton, 12 February 1912. Sarton reflected a lifetime later that Mansion, a devout Catholic, may have associated the word Isis with Freemasonry. Mansion would have known about Sarton's Freemason father and also about Sarton's socialist activity. George Sarton, Why Isis? *Isis, 44* (1953), 232-42.

82.HGS, Max Meyerhof to George Sarton, 18 February 1932.

83.HGS, Paul Masson-Oursel to George Sarton, 15 January 1915. Kishori Lal Sirkar, *An Introduction to the Hindu System of Physics, being an exposition of Kanad-Sutras relating to the subject* (Calcutta, 1911).

84 .HGS, Paul Masson-Oursel to George Sarton, 4 January 1913; Said, *Orientalism*, p. 210.

85.Duncan Black Macdonald, Adela Goodrich-Freer, *Arabs in Tent and Town*, *Isis, 7* (1925), 572; Said, *Orientalism*, pp. 247, 276-7.

86.NYPL, Box 177, Mabel Sarton, copybook dated Ipswich, July 1932: H. A. R. Gibb to George Sarton, 2 June 1947.

87.Joseph Needham, with the research assistance of Wang Ling, *Science and Civilization in China, Volume 1*: *Introductory Orientations* (Cambridge, 1954), p. 7.

88.Diary, 3 February 1920.

89.HGS, Lawrence J. Henderson to George Sarton, 9 February 1920.

90.HGS, George Sarton to Antonio Favaro, 16 March 1920, draft in Italian.

91.Pyenson, Inventory as a Route to Understanding, p. 263.

92.Needham, *Science and Civilization in China, Volume 1*, p. 42.

93.Francesca Bray, Technics and Civilization in Late Imperial China, *Osiris, 13* (1998), 11-33, on p. 14.

94.Said, *Orientalism*, pp. 327-8.

95.Charles W. J. Withers, History and Philosophy of Geography, 2002-2003: Geography in Its Place, *Progress in Human Geography, 29* (2005), 64-72, quotation on p. 67; Withers, AMapping the Niger, 1798-1832: Trust, Testimony and Ocular Demonstration' in the Late Enlightenment, *Imago Mundi, 56* (2004), 170-93.

96.Bernd Hamm, Cynical Science: Science and Truth as Cultural Imperialism, in *Cultural Imperialism: Essays on the Political Economy of Cultural Domination*, ed. Bernd Hamm and Russell Smandych (Peterborough, Ont., 2005), pp. 60-76, on pp. 60-1.

97 .Evan Schofer, The Global Institutionalization of Geological Science,

1800-1990, *American Sociological Review, 68* (2003), 730-59; Willem Wamsteker, Rudolf Albrecht, and Hans J. Haubold, eds, *Developing Basic Space Science World-Wide: A Decade of UN/ESA Workshops* (Dordrecht, 2004), notably the contributions by J. Andersen, D. McNally, and A. H. Batten; Rhys Jones and Richard Phillips, Unsettling Geographical Horizons: Exploring Premodern and Non-European Imperialism, *Annals of the Association of American Geographers, 95* (2005), 141-61.

98.Hardt and Negri, *Empire*, p. 156.

99.Noam Chomsky, Rationality/Science, *Z Papers*, special issue, 1995, available at: http://www.chomsky.info/articles/1995.

100.William A. Cochrane, Killam Lecturer in 2004, has emphasized: Prior to the early 1980s there was suspicion and discomfort on the part of academic scientists to associate with industry; however, this has now changed to where many academic scientists have seen the benefits, both personally and for the institution, and indeed for the country, of more fully cooperating in commercializing their discoveries. Cochrane, *2004 Killam Annual Lecture. Commercializing University Scientific Discoveries: Issues and Challenges* (Halifax, Nova Scotia, [2005]), p. 12.

101 .Lanto Synge, *Art of Embroidery: History of Style and Technique* (Woodbridge, England, 2001), p. 333. Synge is with the antiques firm of Mallett in New Bond Street, London; he has a professional interest in sensing changes of taste and fashion.

102.George Steiner, *Bluebeard's Castle*, pp. 138-9, 133, 130, in sequence.

SARTON MEDAL LECTURES

LAUDATIO GUNDOLF KEIL

Michel Thiery

Heute wird die Sarton-Medaille Gundolf Keil verliehen, dem emeritierten Ordinarius für Geschichte der Medizin an der Universität Würzburg, den ich im Namen der Universität und der Fakultät beglückwünsche und herzlich willkommen heiße.

Wer sich für die Medizingeschichte interessiert, kennt selbstverständlich das Oeuvre unsres Gastes. Es dauerte indessen bis 2004, daß ich ihm zum ersten Mal begegnete, nämlich bei Gelegenheit des Symposiums „Geneeskunde in Nederlandse teksten tot 1600", ausgerichtet von der Ständigen Kommission für Medizingeschichte bei der Koninklijke Academie voor Geneeskunde van België. Das Thema verlangte spezialisierte Sprecher, was die Kommission veranlaßte, Frau Ria Jansen-Sieben (die hier anwesend ist) zu berufen, da die emeritierte Ordinaria für historische Linguistik als die belgische Spezialistin für Mittelniederländische Fachliteratur gilt. Sie war es dann auch, die ihren Lehrer, ihren geistigen Vater Keil, auf dem Symposium vorgestellt hat, wo seine überaus gelehrte Analyse des weniger bekannten Werks unseres Jan Yperman, des ‚Boecks der Medicinen', einen so großen Eindruck auf zwei Personen machte, die unsere Fakultät im Sarton-Komitee repräsentieren - Prof. Robert Rubens und meine Wenigkeit -, daß sie ihn für die Sarton-Medaille vorschlugen.

Soweit, meine Damen und Herren, der Hintergrund dieses Ereignisses: daß das Bekanntmachen, vermittelt durch Ria Jansen-Sieben (die ihrerseits mit der Sarton-Medaille 1996 ausgezeichnet worden war), zur Einsicht führte, daß es höchste Zeit sei, daß Prof. Keil – Ria nennt ihn den Deutschen Papst der Medizingeschichte – auch durch unsre Fakultät ausgezeichnet werde für seinen weltweit wahrgenommenen Beitrag zur Geschichte der Medizin, insbesondere jener des Mittelalters.

Es folgt nun, liebe Hörer, die offizielle Vorstellung, die Laudatio für den Gelehrten, mit der die Fakultät mich beauftragt hat:

Gundolf Keil wurde am 17. Juli 1934 in Wartha geboren. Er durchlief seine Schulausbildung in Rostock, bei Karlsruhe und im schweizerischen Zürich. Danach studierte er Germanistik, Klassische Philologie, Philosophie, Geographie und Ethnologie sowie schließlich auch Medizin an drei

führenden deutschen Universitäten, nämlich Heidelberg, Göttingen und Bonn.

1961 promovierte er in Heidelberg in den philologischen Fächern, 1961/62 legte er in den fünf geisteswissenschaftlichen Fächern die Staatsexamina für den Höheren Schuldienst ab; 1968 bestand er das Medizinische Staatsexamen und promovierte ein Jahr später zum Doktor der Medizin.

Von Beginn seines Medizinstudiums an befaßte er sich mit der Geschichte seines Fachgebiets und arbeitete als Assistent, später als Oberassistent an den Medizinhistorischen Instituten der Universitäten Bonn und Göttingen.

Unmittelbar nach der medizinischen Promotion startete er seine akademische Laufbahn: 1969 wurde er zum Professor ernannt und auf den zweiten germanistischen Lehrstuhl der königlichen Universität Stockholm berufen; 1970/71 habilitierte er sich für Medizingeschichte an der Universität Freiburg im Breisgau, erwarb den Titel eines Privatdozenten und übernahm noch im gleichen Jahr die Direktion des Instituts für Geschichte der Medizin an der Universität Marburg (Lahn). Die Rufe auf die medizinhistorischen Ordinariate von Marburg und Würzburg erreichten ihn im Frühjahr 1972, und im Dezember desselben Jahres wurde er zum Vorstand des Würzburger Instituts für Geschichte der Medizin ernannt. Der Würzburger Universität blieb er treu, auch als er 1985 auf den medizinhistorischen Lehrstuhl der Bonner Universität berufen wurde. Nach der Emeritierung 2003/04 blieb er der Motor und Inspirator der „Wullstein-Forschungsstelle für deutsche Medizinliteratur des Mittelalters", des weltweit bekannten Forschungsinstituts für heilkundliche Literatur des Medium Aevum, und wirkte er weiter als Vorstand und Spiritus rector des „Gerhard-Möbus-Instituts für Schlesienforschung an der Universität Würzburg".

Seine Emeritierung wurde glanzvoll gefeiert. Kollegen aus vielen Ländern hielten Vorträge. Zwei ständige Mitarbeiter überreichten ihm die dickleibige „Festschrift für Gundolf Keil", deren Untertitel „Medizin in Geschichte, Philologie und Ethnologie" die drei belangreichsten Gebiete angibt, auf denen der Meister seine Sporen verdient hat. Ria Jansen-Sieben hielt den Festvortrag und erinnerte daran, daß Keil sein Institut entwickelt hatte zum Zentrum, wo Forscher aus vielen Ländern aufgenommen wurden und wo er zahlreiche von ihnen bei ihren Promotions- und Habilitationsarbeiten leitete; daß er an seinem Institut die Studenten in medizinischer Fachterminologie unterrichtete, daß er zwei Reihen Monographien herausgab und daß er jährlich ein Kolloquium zur

Medizingeschichte organisierte. Ria skizzierte auch den Menschen Keil, den scharfen, aber niemals ausfallenden Kritiker, als dessen Wesensmerkmal sie die Generosität hervorhob und den Altruismus, die ständige Hilfsbereitschaft unterstrich.

Keil ist Herausgeber bzw. Mitherausgeber tonangebender Zeitschriften und Fortsetzungswerke wie von ‚Sudhoffs Archiv' und vom ‚Verfasserlexikon' zur ‚deutschen Literatur des Mittelalters'; er ist Träger von nicht weniger als drei Doktortiteln, er ist Mitglied der New York Academy of Sciences, der Mediaeval Academy of America, und er empfing die Avicenna-Medaille der Universität Istanbul sowie die Avicenna-Plakette der Medizinischen Akademie zu Krakau. Er hat in gradezu überbordendem Umfang publiziert und schrieb Hunderte von Biobibliographien berühmter, aber auch bislang unbekannter, durch ihn entdeckter Ärzte und Wundärzte. Als eine wahre Schatzkammer an Fakten und Begebenheiten, die wir seit diesem Jahr nachschlagen können, erweist sich die ‚Enzyklopädie Medizingeschichte', als deren Initiator und Mitherausgeber er zeichnet. Es handelt sich um ein Buch, das in keiner medizinhistorischen Bibliothek fehlen sollte und das auf der Stelle den Segen von George Sarton bekommen würde -: von George Sarton, von dem Keil schreibt: „Sarton, den ich sehr verehre und der hier gleich greifbar neben mir mit seiner ‚Introduction to the History of Science' steht".

Die mittelniederländische Literatur ist ein Themenfeld, mit dem sich Keil seit genau 45 Jahren befaßt. Darum entschloß er sich auch, uns heute mit einer auf Niederländisch gehaltenen Vorlesung zu erfreuen, die von einem seiner Helden, dem West-Flamen Jan Yperman handelt - Keil bezeichnet ihn als die überragende Gestalt unter den mittelniederländischen Fachprosa-Autoren.

Meine Damen und Herren, es ist höchste Zeit, daß ich meine Vorstellung abschließe und unserm Gast das Wort erteile: Kollege Keil, Sie haben das Wort.

JAN YPERMAN UND DIE NIEDERLÄNDISCHE CHIRURGIE IM SPÄTMITTELALTER

Gundolf Keil

Über alle Zeiten hinweg versuchten die Chirurgen, die Hilfe für ihre Patienten zu verbessern, und sie versuchten diese Optimierung vor allem durch Verbesserung ihrer traumatologischen Verfahren und ihres operativen Vorgehens zu erzielen[1]. Aspekte der Diätetik, Pflege, Hospitalisierung traten hinzu[2]. Beim Blick auf die Gesamtentwicklung ist es entsprechend richtig zu sagen: „De geschiedenis van de heelkunde is dan ook een verhaal van en kunde en van een wetenschap, die in het teken staat van de vooruitgang"[3]. Die zunehmende theoretische Durchdringung des Wissens[4] ist in dieser Aussage miterfaßt.

Am Fortschritt der Chirurgie haben Wundärzte aus den Südlichen Niederlanden[5] einen größeren Anteil, als gemeinhin bekannt und bewußt ist[6]. Im allgemeinen Bewußtsein sind am ehesten die Namen von Scellinck[7],

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[1] Michael SACHS, Geschichte der operativen Chirurgie „in fünf Bänden", Heidelberg 2000-2005

[2] Ralf VOLLMUTH, Traumatologie und Feldchirurgie an der Wende vom Mittelalter zur Neuzeit, exemplarisch dargestellt anhand der ‚Großen Chirurgie' des Walther Hermann Ryff, Stuttgart 2001; Gundolf KEIL Aphorismen zur Krankenhausgeschichte, in: Arnulf THIEDE und Heinz-Jochen GASSEL, Krankenhaus der Zukunft, Heidelberg 2006, S. 737-742

[3] François NARMON, Woord vooraf, in: In de voetspoeren van Yperman: Heelkunde in Vlaanderen door de eeuwen hen, hrsg. von Robrecht VAN HEE, Gent 1990, S. 1

[4] Sie führt wissenschaftstheoretisch auf schwieriges Terrain; vgl. zur Problematik Sönke DREWSEN, Grundzüge einer Möglichkeit, die Medizin als Wissenschaft zu beschreiben. Überlegungen zur Metamedizin, med. Diss. Würzburg 2005

[5] die wir seit 1831 ‚Belgien' nennen

[6] NARMON (1990) [wie Anm. 1]

[7] das ist Thomaes Schelling van T(h)ienen; vgl. den entsprechenden Artikel von Bernhard Dietrich HAAGE, in: Lexikon des Mittelalters [abgekürzt: LexMA],

Vesalius[8] und Jan Palfyn[9] haften geblieben, aber neben diesen standen zahlreiche nicht minder bedeutende Chirurgen, die vor allem in den Städten, aber auch in ländlicher Umgebung tätig waren und das Ihre zur fachlichen Entwicklung der Heilkunde beitrugen.

Über den Leistungsstand niederländischer Chirurgie ist aus der Zeit vor 1300 wenig bekannt[10]. Fachliteratur im engeren Sinne fehlt[11], und nur einige Gesundheitsregimina geben in äußerst knapper Form Vorschriften für den Aderlaß[12]. Auf jeden Fall kann davon ausgegangen werden, daß die niederländische Heilkunde zumindest den gleichen (wenn nicht einen noch

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München und/oder Zürich I-X, (1977-)1980-1999, leicht gekürzter Neudruck in neun Bänden Stuttgart und Weimar 1999, hier VII (1995), Sp. 1448

[8] das ist Andries Witting van Wesel te Brussel, latinisiert Andreas Vesalius Bruxellensis

[9] Zu der durch ihn ermöglichten Einführung der Geburtszange sieh Thomas SCHNECK in: Werner E[rich] GERABEK, Bernhard D[ietrich] HAAGE, Gundolf KEIL und Wolfgang WEGNER (Hrsgg.), Enzyklopädie Medizingeschichte [abgekürzt: **EnzMedGesch**]; Hanna ENDERS, Scanzoni in Würzburg, Würzburg 2005 (= Würzburger medizinhistorische Forschungen, 86), S. 7 und 223

[10] Ria JANSEN-SIEBEN, De heelkunde in Vlaanderen tijdens de late middeleeuwen, in: de voetspoeren (1990) [wie Anm. 1], S. 67-77

[11] Ria JANSEN-SIEBEN, Middelnederlandse vakliteratuur, in: Fachprosaforschung. Acht Vorträge zur mittelalterlichen Artesliteratur, hrsg. von Gundolf KEIL und Peter ASSION, Berlin 1974, S. 24-69, besonders S. 46-48 und 67f.; sieh auch DIES., Repertorium van de Middelnederlandse artesliteratuur, Utrecht 1989, S. 36-40

[12] Vgl. G. KEIL, Aderlaß, in: LexMA [wie Anm. 7], I (1980), Sp. 150f.; Bettina GÖTTE, Laßlunare. Untersuchungen zur mittelalterlichen Lunarliteratur unter besonderer Berücksichtigung des Aderlasses, med. Diss. Würzburg 1996; DIES., Ein Sammellunar aus dem Schlettstädter Kodex 49, Würzburger med.hist. Mitt. 20 (2001), S. 168-178; Christine BOOT, „an aderlaszen ligt grosz gesuntheit". Zur Repräsentanz von Ortolfs Phlebotomie in deutschsprachigen Aderlaßtraktaten, in: „ein teutsch puech machen". Untersuchungen zur landessprachlichen Vermittlung medizinischen Wissens. Ortolf-Studien, 1, hrsg. von Gundolf KEIL, redig. von Johannes G[ottfried] MAYER und Christian NASER, Wiesbaden 1993 (= Wissensliteratur im Mittelalter, 11), S. 112-157; vgl. auch Gerrit BAUER (Hrsg.), Das ‚Haager Aderlaßbüchlein' (= Studien zum ärztlichen Vademecum des Spätmittelalters, I), Pattensen bei Hannover [jetzt: Würzburg] 1978 (= Würzburger medizinhistorische Forschungen, 14), sowie Anm. 76

höheren) Stand zeigte wie in den übrigen Regionen des Deutschen Reichs. Ein kontrastiver Vergleich, der sich neben fiktionalen Texten[13] auch auf ikonographische Quellen und archäologische Funde[14] stützen müßte, steht indessen noch aus.

Im Mittelalter und schon lange davor[15] war die Chirurgie eine von den drei Säulen, auf denen die Medizin ruhte (bei den andern beiden handelte es sich um die Pharmazie[16] und die Diätetik[17]). Indessen genoß sie im Vergleich mit der „Physica" (oder Inneren Medizin) seit dem Hochmittelalter

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[13] Sieh als Beispiel die richtungweisende Untersuchung von Bernhard Dietrich HAAGE, Studien zur Heilkunde im ‚Parzival' Wolframs von Eschenbach, Göppingen 1992 (= Göppinger Arbeiten zur Germanistik, 565), und vgl. auch: Die Thorakozentese in Wolframs von Eschenbach ‚Parzival', Würzburger med.hist. Mitt. 2 (1984), S. 79-99; DERS., Der Ritter Gawan als Wundarzt (Parz. 506.5ff.), in: Würzburger Fachprosa-Studien. Beiträge zur mittelalterlichen Medizin-, Pharmazie- und Standesgeschichte aus dem Würzburger medizinhistorischen Institut. Fschr. Michael Holler, hrsg. von Gundolf KEIL, Würzburg 1995 (= Würzburger medizinhistorische Forschungen, 38), S. 1-24

[14] Vgl. die beispielhafte Studie von Hans-Georg STEFAN, Der Chirurg von der Weser (ca. 1200-1265) – ein Glücksfall der Archäologie und Medizingeschichte, Sudhoffs Arch. 77 (1993), S. 178-192; vgl. auch: G. KEIL, Chirurg von der Weser, in: LexMA [wie Anm. 7], II (1983), Sp. 1859f.; DERS., dass., in: VL [wie Anm. 33], I, (1978), Sp. 1196f.

[15] Wolfhart WESTENDORF, Papyrus Edwin Smith, ein medizinisches Lehrbuch aus dem Alten Ägypten. Wund- und Unfallchirurgie, Zaubersprüche gegen Seuchen, verschiedene Rezepte. Aus dem Altägyptischen übersetzt, kommentiert und hrsg., Bern und Stuttgart 1966 (= Hubers Klassiker der Medizin und der Naturwissenschaften, 9); vgl. auch G. KEIL, Der Papyrus Ebers und die Medizin des Abendlandes, in: Papyrus Ebers und die antike Heilkunde. Akten der Tagung ... 2002 in der Albertina/UB der Universität Leipzig, hrsg. von Hans-Werner FISCHER-ELFERT, Wiesbaden 2005 (= Philippika, 7), S. 11-40

[16] Rudolf SCHMITZ unter Mitwirkung von Franz-Josef KUHLEN, Christoph FRIEDRICH und Wolf-Dieter MÜLLER-JAHNCKE, Geschichte der Pharmazie, I-II, Eschborn 1998-2005

[17] G. KEIL, „regimen sanitatis – râtes leben". Gesundheitsregeln des Mittelalters, in: Voeding en geneeskunde. Acten van het colloquium Brussel ... 1990, uitg. door Ria JANSEN-SIEBEN en Frank DAELEMANS, Brussel 1993 (= Archief- en bibliotheekwezen in België, extranummer 41), S., 95-124; Dietrich VON ENGELHARDT, Diätetik, in: EnzMedGesch (2005) [wie Anm. 9], S. 299-303

ein nur geringes Ansehen[18]. Die Ursache hierfür ist komplex[19] und resultiert unter anderm aus der Tatsache, daß die Wundärzte zünftisch mit den Badern zusammengingen und sich häufig mit ihnen in einundderselben Gilde zusammenschlossen. Die „Bademeister" indessen zählten – ebenso wie die Abdecker, Scharfrichter, Lohnkämpen – zu den „unehrlichen Berufen"[20]:

„Der bademeister und sein gesind'
allez buoben und huoren sint".

Die Bader übten keinen eigentlichen Lehrberuf aus, insofern als an das Eröffnen einer Badstube keinerlei Voraussetzungen hinsichtlich einer Berufsausbildung geknüpft waren[21]; sie galten vielerorts als ‚rechtlos', was indessen nur soviel bedeutete, daß sie gesellschaftlich marginalisiert wurden und wie die Schinder, Scherenschleifer, Kesselflicker, Dirnen, Bordellwirte, Bettler, Spielleute und Zigeuner zu jenen sozialen Randgruppen gehörten, die ‚niedere', ‚schmutzige', ‚verachtete Tätigkeiten' ausübten und von bestimmten Rechtshandlungen ausgeschlossen blieben. Da Unehrlichkeit gleichsam als ‚ansteckend' galt und diejenigen, die mit Unehrlichen persönlichen Umgang pflegten, gleichfalls unehrlich machte, war das körperschaftliche Zusammengehn mit den Badern für Wundärzte nicht ohne gesellschaftliches Risiko. Das Ansehen der Chirurgie nahm Schaden[22], und

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[18] G. KEIL, Chirurg, Chirurgie, in: LexMA [wie Anm. 7], II (1983), Sp. 1845-1859; Bernhard D[ietrich] HAAGE, Wolfgang WEGNER und Christoph WEISZER, Chirurgie, in: EnzMedGesch (2005) [wie Anm. 9], S. 250-257; DOMINIK GROSS, Die Aufhebung des Wundarztberufs. Ursachen, Begleitumstände und Auswirkungen am Beispiel des Königreichs Württemberg, Stuttgart 1999 (= Sudhoffs Archiv, Beih. 41)

[19] Hans-Peter BAUM/G. KEIL/Gerhard BAADER, Bader [und] Badewesen, in: LexMA [wie Anm. 7], I (1980), Sp. 1339-1441, sowie VIII (1997), Sp. 1216: „unehrliche Leute", „verachtete Berufe"

[20] Erwin HUIZENGA, „Een nuttelike practijke van cirurgien". Geneeskunde en astrologie in het Middelnederlandse handschrift Wenen, Österreichische Nationalbibliothek, 2818, phil. Diss. Groningen, Hilversum 1997 (= Middeleeuwse studies en bronnen, 54), S. 249

[21] Das bedeutet freilich keineswegs, daß sich für Bader nicht Ende des Mittelalters zünftische Ausbildungsstrukturen herausgebildet hätten; vgl. die Nachweise bei HUIZENGA (1997), S. 247f.

[22] a.a.O., S. 238; vgl. auch Erwin HUIZENGA, Tussen autoriteit en empirie. De Middelnederlandse chirurgieën in de veertiende en vijftiende eeuw en hun maatschappelijke context, Hilversum 2003 (= Artesliteratuur in de Nederlanden, 2), S. 227-229

wie der Fakultätenstreit des 14. und 15. Jhs. zeigt[23], brachte die unscharfe Abgrenzung zu den benachbarten handwerklichen Berufsgruppen schließlich die gesamte Medizin in Mißkredit. Juristischerseits war man bereit, ihr die Zugehörigkeit zu den Wissenschaften abzusprechen und sie als „ars mechanica" aus der Universität zu verbannen.

Nachdem mit den frühen Salerner Ärzten die scholastische Methode in die Medizin Eingang gefunden hatte, gewann in der Heilkunde die theoretische Durchdringung und Aufbereitung des Wissens zunehmend an Bedeutung. Dieser Entwicklung konnten sich selbst die praxisbezogenen Bereiche operativer Chirurgie nicht entziehen. Indem auch die Wundärzte verstärkt darauf achteten, ihr Wissen nach theoretisch-wissenschaftlichen Aspekten zu ordnen, begann die Kluft zwischen Akademiker- und Wundärzten schmaler zu werden. Hinzu kam, daß man danach trachtete, die manuell-praktischen Dimensionen der Chirurgie zu bagatellisieren[24].

Die Folge war, daß sich die Kluft zwischen akademisch ausgebildeten und praxisorientierten Fachvertretern nun in der Chirurgie auftat. Auf der einen Seite finden wir seit 1200 die Wundärzte ‚mit der langen Toga', die – in Parma, Bologna, Montpellier oder Paris unterrichtet – dasselbe theoretische Wissensniveau erreichten wie die universitär ausgebildeten „doctores medicinae" (wobei sie freilich die praktische Seite der „wunt-arzenîe" nicht selten vernachlässigten); auf der andern Seite begegnen die überwiegend zünftisch ausgebildeten Empiriker, denen als Handwerkschirurgen das theoretische Gerüst ihres Faches nur unzureichend geläufig war. Die Chirurgie zerfiel auf diese Weise in zwei Bereiche, einen theorielastig-wissenschaftlichen und einen empiriegestützten praktischen. Die Auswirkungen auf die Gesamt-Medizin waren im Spätmittelalter dramatisch, und erst im 17. bzw. 18. Jh. sollten Theorie und Praxis sich wieder aufeinander zubewegen: Chirurgen wurden – nicht zuletzt unter Einfluß ihrer Zünfte[25] – zunehmend besser ausgebildet, während sich bei den

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[23] Gundolf KEIL und Rudolf PEITZ, „Decem quaestiones de medicorum statu". Beobachtungen zum Fakultätenstreit und zum mittelalterlichen Unterrichtsplan Ingolstadts, in: Der Humanismus und die oberen Fakultäten, hrsg. von Gundolf KEIL, Bernd MOELLER und Winfried TRUSEN, Weinheim und Bonn 1987, S. 215-238

[24] HUIZENGA (1997) [wie Anm. 20], S. 237f.

[25] GROSS (1999) [wie Anm. 18], S. 45f., 48, 207, 268 u. ö.; sieh auch Dominik GROSS, Der „Verein württembergischer Wundärzte und Geburtshelfer" (1847/48-1919). Eine fast vergessene Interessenorganisation, Würzburger med.hist. Mitt. 18 (1999), S. 335-358(-374)

Akademikerärzten ein wachsendes Interesse an praktischen Aspekten ärztlichen Tätigseins regte. Schließlich unterschieden sich die beiden Berufsgruppen nur noch durch das Führen der „doctor"-Bezeichnung in der Titulatur.

Im späten Mittelalter zeigten sich die Unterschiede in schärferen Konturen: Es war den Chirurgen strikt untersagt[26], sich auf dem Gebiet der Inneren Medizin zu betätigen[27]: dies blieb vorbehalten den akademisch ausgebildeten „doctores medicinae". Es spielte sich indessen ein fortdauernder Streit zwischen Akademikerärzten und Wundärzten ab, der die Abgrenzung der Tätigkeitsfelder betraf und beispielsweise dadurch verschärft wurde, daß die Chirurgen sich das Modell der ‚inversen Purgaz' zueigen machten, das sie beim *wunt-tranc*-Verordnen zwang, ihre Flüssig-Arzneimittel per os zu verabfolgen[28]. Aber im allgemeinen resultierte aus den Auseinandersetzungen, daß jede nur erdenkliche äußerliche Anwendung – auch die an Mund, Auge, Ohr, Blase, After, Genitalien – in den Kompetenzbereich der Chirurgen fiel. Die zunehmende Bereitschaft zu invasiven Eingriffen [29] führte dazu, daß die Berufsgruppe sich im

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[26] Die geringe Arztdichte in bezug auf Akademikerärzte schloß das Einhalten dieses Verbots bis weit ins 19. Jh. hinein aus; vgl. GROSS (1999) [wie Anm. 18], S. 207 sowie 268, und sieh hinsichtlich eines internmedizinischen Rezeptars für Chirurgen Hans Michael WELLMER, Die ‚Würzburger Wundarznei'. Ein chirurgisches Arzneimittel-Handbuch des Spätmittelalters. Textausgabe, Teil XI/2: Edition des chirurgischen Rezeptars, das auf den Wässer-Traktat folgt, med. Diss. Würzburg 2005

[27] HUIZENGA (1997) [wie Anm. 20], S. 234

[28] Vgl. Klaus MÜLLER, Die ‚Würzburger Wundarznei'. Ein chirurgisches Arzneimittel-Handbuch des Spätmittelalters. Textausgabe, Teil VIII: Edition des achten Segments (Wundtränke), med. Diss. Würzburg 2003; K. MÜLLER und G. KEIL zusammen mit Hilde-Marie GROSS, „Wundtränke" in der deutschen medizinischen Fachprosa des 13. bis 15. Jahrhunderts. Studien zum mittelalterlichen Bedeutungsumfeld eines Erstbelegs im ‚Breslauer Arzneibuch', Acta historica et museologica Universitatis silesianae Opaviensis 6 (2003), S. 119-141

[29] Das gilt beispielsweise für einen der führenden oberdeutschen Chirurgen des 15. Jhs., sieh Manfred GRÖBER (Hrsg.), Das wundärztliche Manual des Meisters Hans Seyff von Göppingen (ca. 1440-1518): Der Cod. med. et phys. 2° 8 der Württembergischen Landesbibliothek Stuttgart, Göppingen 1998 (= Göppinger Arbeiten zur Germanistik, 656)

Spätmittelalter weiter unterteilte, und zwar in die nicht spezialisierten Wundärzte und die mehr operativ tätigen Schnittärzte[30].

Der Tätigkeitsbereich der Chirurgen war entsprechend den geschilderten Voraussetzungen weit gefächert: Wundärzte arbeiteten als Arzneimittelpro-duzenten unter Nutzung einer komplexen pharmazeutischen Technologie; sie verfaßten Arzneimittel-Handbücher, waren geübt in der Lagerhaltung und stellten ihre (meist äußerlich anzuwendenden) Standardpräparate selber her, wo-bei davon auszugehen ist, daß das Volumen ihrer Composita-Produktion größer war als diejenige der Apotheker[31]. Da sie als Grundlage für ihre Pflaster (und Salben) Wachs verwendeten, traten sie auch als Kerzenzieher und Devotionalienhändler auf[32].

Auf Jahrmärkten begegnen sie als fahrende Drogenhändler; beim Sammeln von Heilkräutern [33] betätigten sie sich konkurrierend zu Kräuterweibern, die nach den Richtlinien von Kräuter-Sammel-Kalendern

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[30] Aufgrund seiner fachlichen Spezialisierung nennt sich beispielsweise der Zürich-Lindauer Chirurg Stromayr „Schnidt vnnd augen Artzt"; vgl. Caspar STROMAYR, Practica copiosa von dem rechten Grundt des Bruch Schnidts (Lindau, 1559-67), & Jakob RUËFF, Practica in arte ophthalmica copiosa (Zürich, um 1550), [I: Faksimile, II:] Kommentar zur Faksimile-Ausgabe unter besonderer Berücksichtigung der Paracelsus-Rezeption und der Kommunikationsstruktur in chirurgischen Geheimbüchern der frühen Neuzeit, von Peter PROFF und Gundolf KEIL, Darmstadt 1994, hier II, S. 20

[31] Dagmar SCHELLETTER, Anne RAPPERT und G. KEIL, Aphorismen zur Arzneiform „Salbe" unter Berücksichtigung chirurgischer Fachprosa des deutschen Mittelalters, in: Pratum floridum. Fschr. Brigitte Hoppe, hrsg. von Menso FOLKERTS, Stefan KIRSCHNER und Andreas KÜHNE, Augsburg 2002 (= Algorismus. Studien zur Geschichte der Mathematik und der Naturwissenschaften [= Münchener Universitätsschriften], 38), S. 369-403, hier S. 398

[32] HUIZENGA (2003) [wie Anm. 22], S. 221

[33] Gute Heilkräuter-Kenntnis zeigt beispielsweise der Wundarzt Klaus von Matrei; vgl. Peter ASSION, K. v. M. („Metry"), in: Die deutsche Literatur des Mittelalters. Verfasserlexikon [abgekürzt: VL]. Zweite, völlig neu bearbeitete Aufl. hrsg. von Gundolf KEIL, Kurt RUH [federführend bis Bd. VIII (1992)], Werner SCHRÖDER, Burghart WACHINGER [federführend ab Bd. IX (1995)] und Franz Josef WORSTBROCK, I-XII, Berlin und New York (1977-)1978-2006, hier IV (1983), Sp. 1190-1193; Ralf VOLLMUTH, War Klaus von Matrei der Lehrer Hans von Gersdorffs? Sudhoffs Arch. 80 (1996), S. 109-117

beim Ernten vorgingen[34]. Das Spektrum traumatologischer Eingriffe fächerte von der Wundtoilette bis zum Therapieren von Impressionsfrakturen auf; Knochenbrüche der Extremitäten wurden durch Schienen und erstarrende Verbände fixiert; aus Biegungsbrüchen des Schädeldachs wurden die Knochenfragmente entfernt; komplizierte Brüche hielt man bis zur Kallusbildung offen: Beinladen übernahmen die Funktion eines ‚fixateur externe'. Abszesse brachte man zur Reife; im Entleeren von Eiter sah die humoralpathologische ‚Apostasen'-Lehre eine willkommene Ausscheidung schädlicher Säfte. Geschwülste hat man, soweit von außen zugänglich, total entfernt, wobei neben dem Skalpell auch Ätzmittel und das Brenneisen zum Einsatz kamen. Das Glüheisen benutzte man freilich auch zur Blutstillung; daneben kannte die Chirurgie – vergleichbar fernöstlicher Moxibustion – das therapeutische Kauterisieren, das (entsprechend den Schröpf- oder Laßmännlein) der Vorgabe figürlicher Brennstellen-Schemata folgte[35]. In Kriegszeiten galt es, steckengebliebene Projektile (Speer-, Pfeilspitzen, Kugeln) aus den Schuß- bzw. Stichkanälen zu entfernen, wozu die niederländische Chirurgie komplexe Extraktionsgeräte entwickelte[36]. Besondere chirurgische Verfahren galten dem Starstich[37], der Lithotomie,

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[34] Ulrich STOLL, „De tempore herbarum". Vegetabilische Heilmittel im Spiegel von Kräuter-Sammel-Kalendern des Mittelalters. Eine Bestandsaufnahme, in: Rhythmus und Saisonalität. Kongreßakten des 5. Symposions des Mediävistenverbandes in Göttingen 1993, hrsg. von Peter DILG, G. KEIL und Dietz-Rüdiger MOSER, Sigmaringen 1995, S. 347-375

[35] Vgl. die entsprechenden Kapitel im I. Band von: Karl SUDHOFF, Beiträge zur Geschichte der Chirurgie im Mittelalter, I-II, Leipzig 1914-1918 (= Studien zur Geschichte der Medizin, 10-11/12), und sieh auch Max KÜNZEL, Beilngrieser Aderlaßmännlein, Würzburger med.hist. Mitt. 19 (2000), S. 153-176 [mit Faksimile]; G. KEIL, Schröpfen, in: Reallexikon der Germanischen Altertumskunde, XXVII, hrsg. von Heinrich BECK, Dieter GEUENICH, Heiko STEUER, redig. von Rosemarie MÜLLER, Berlin und New York 2004, S. 337-341

[36] J[ean] P[ierre] TRICOT, Jehan Yperman, Vader der Vlaamse heelkunde, in: de voetspoeren (1990) [wie Anm. 3], S. 78-86, hier S. 81 [mit Abb.]; vgl. auch Ralf VOLLMUTH, ... zur Behandlung von Schußwunden durch Feuerwaffen ..., Würzburger med.hist. Mitt. 17 (1998), S. 205-214; Sudhoffs Arch. 82 (1998), S. 102-104

[37] Wobei die Linse durch Reclinatio lentis nach unten umgelegt oder durch eine feine Kanüle ab- bzw. extrakapsulär ausgesaugt wurde; vgl. PROFF/KEIL (1994) [wie Anm. 30], II, S. 26, 34, 36, 47

der hodenschonenden Operation des direkten Leistenbruchs [38], der Umstechung von Arterien zur Blutstillung[39] und der operativen Exstirpation von Gliomen bzw. Meningeomen[40] unter Vollnarkose[41]. Beim Aderlassen und Schröpfen traten die Bader zunehmend als Konkurrenten auf, die den Wundärzten im Spätmittelalter auch weite Areale der Dermatologie streitig machten[42], darunter die Behandlung von Brandwunden und Ulcera cruris. Hier sind sie im späten 15. Jh. auch mit einer eigenen Lehrschrift hervorgetreten[43], in der sie sich keineswegs auf das Bereiten von Heilbädern beschränken, sondern auch eine spezielle Traumatologie bereitstellen.

Was die wundärztliche Pharmazie betrifft, so manifestiert sie sich seit dem 14. Jh. in chirurgischen Rezeptsammlungen, die sich im 15. Jh. zu Arzneimittel-Handbüchern ausweiten, wobei sich die Anordnung nach Arzneiformen[44] als strukturbestimmendes[45] Ordnungsprinzip durchzusetzen

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[38] a.a.O., S. 26-28, 33 [Kap. 13]

[39] HUIZENGA (1997) [wie Anm. 20], S. 165; GRÖBER (1998) [wie Anm. 29], Kap. 205f., S. 106, 110, 366 und 458

[40] Auf den entsprechenden „noordoostelijke" Text des 14. Jhs. werde ich in einer gesonderten Untersuchung noch zurückkommen

[41] Vgl. zur mittelalterlichen Vollnarkose: G. KEIL, Geleitwort, in: Illustrierte Geschichte der Anästhesie, hrsg. von Ludwig BRANDT zusammen mit Karl-Hans BRÄUTIGAM, Michael GOERIG, Csaba NEMES und Hans NOLTE, Stuttgart 1997, S. V^a-X^c, und sieh auch G. KEIL, ‚Traktat von den schlafmachenden Stücken nach der arabischen Weise' (‚Ars somnifera'), in: VL [wie Anm. 33] IX (1995), Sp. 997f.

[42] PROFF/KEIL (1994) [wie Anm. 30], II, S. 18f.

[43] Ingrid ROHLAND, Das ‚Buch von alten Schäden'. Teil II: Kommentar und Wörterverzeichnis, Pattensen bei Hannover [jetzt: Würzburg] 1982 (= Würzburger medizinhistorische Forschungen, 23)

[44] Knut BENTELE und Gundolf KEIL, Die ‚Würzburger Wundarznei'. Anmerkungen zu einem neugefundenen Arzneimittel-Handbuch des Spätmittelalters, in: Scrinium berolinense. Fschr. Tilo Brandis, hrsg. von Peter Jörg BECKER, Eva BLIEMBACH, Holger NICKEL, Renate SCHIPKE und Giuliano STACCIOLI, I-II, Berlin 2000 (= Beiträge aus der Staatsbibliothek Preußischer Kulturbesitz zu Berlin, 10), hier I, S. 358-382

[45] Und zwar in ab- (oder auf)steigender Kondensreihe; vgl. SCHELLETTER/RAPPERT/KEIL (2002) und sieh auch Petra HILLE, Die Arzneiform *Pulver* in der chirurgischen Fachliteratur des Hoch- und Spätmittelalters (unter besonderer Berücksichtigung der Würzburger Wundarznei), in: Ditor ut ditem. Tanulmányok Schultheisz Emil professzor 80. Születés napjára, hrsg. von István GAZDA, Károly KAPRONCZAY, Laszló

beginnt. Während ‚Jonghe Lanfranc'[46] und ‚Utrechter Arzneibuch'[47] noch nach Indikation und Leitdroge ordnen, setzt sich im Anschluß an Peter von Ulm[48] die pharmazeutische Makrostruktur durch, die den Formelbestand nach Arzneiformen gruppiert und in der Folge *Pflaster*, *Salben*, *Pulver*, *Wässer*[49], *Wundtränke*, *Gebrannte Wässer*, *Öle*[50], *Balsame*[51] reiht.

Obwohl ab dem 9. Jh. Vollnarkosen möglich waren[52], wurden die meisten Eingriffe ohne Betäubung durchgeführt. Welche Schmerzen die Patienten auszuhalten hatten, ist schwer vorstellbar. Es ereignete sich häufig, daß nicht allein der Patient, sondern auch Zuschauer und selbst Gehilfen, die dem Operateur assistierten, in Ohnmacht fielen. Für die Allgemeinheit galten operierende Chirurgen als roh und gefühllos, und dieses

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András MAGYAR u.a., Ofen: Semmelweis Orvostörténeti Múzeum, Könyvtár es Levéltár 2003, S. 54-104, besonders S. 74-78

[46] Erwin HUIZENGA, Het wonderbaarlijke leven van meester Jan Framons. Handschriftelijke context, structuur en intentie van de Middelnederlandse overlevering van de Jonghe Lanfranc, in: Artes in context. Opstellen over het handschriftelijke milieu van Middelnederlandse artesteksten. Fschr. Peter Gumbert, hrsg. von Orlanda S. H. LIE und Joris REYNAERT, Hilversum 2004 (= Artesliteratuur in de Nederlanden, 3), S. 99-148

[47] Textsegment Cc, vgl. Agi LINDGREN und G. KEIL, ‚Utrechter Arzneibuch', in: VL [wie Anm. 33], X (1999), Sp. 145-148

[48] G. KEIL, Die ‚Cirurgia' Peters von Ulm. Untersuchungen zu einem Denkmal altdeutscher Fachprosa mit kritischer Ausgabe des Textes, Ulm 1961 (= Forschungen zur Geschichte der Stadt Ulm, 2); DERS., Peter von Ulm, in: VL VII (1989), Sp. 458-464

[49] Tee-artige Absude (Dekokte)

[50] Absude (Dekokte) oder unter Sonneneinwirkung digerierte Mazerationen auf Baumöl-Grundlage; vgl. Christian CRONE, Anne RAPPERT und Gundolf KEIL, Arzneiöle als formbestimmendes Element in der chirurgischen Fachliteratur des Spätmittelalters, in: Rosarium litterarum. Beiträge zur Pharmazie- und Wissenschaftsgeschichte, zusammen mit Daniela SCHERHORN hrsg. von Christoph FRIEDRICH und Sabine BERNSCHNEIDER-REIF, Eschborn 2003, S. 67-104

[51] Ätherische Öle (Destillate) oder auch gekrachtes Baumöl; vgl. G. KEIL, ‚Benediktenöl-Traktat', in: VL [wie Anm. 33], XI (2004), Sp. 236f.

[52] Daniël DE MOULIN, De heelkunde in de vroege middeleeuwen, Leiden 1964, S. 145 u.ö.; G. KEIL, Spongia somnifera. Mittelalterliche Meilensteine auf dem Weg zur Voll- und Lokalnarkose, Anaesthesist 38 (1989), S. 643-648; KEIL (1997) [wie Anm. 41]

Rollenverständnis war so tief eingewurzelt, daß mitfühlende Wundärzte nicht geduldet und von ihnen die erwartete Brutalität eingefordert wurde[53].

Niedergelassene Wundärzte waren in Gilden organisiert, deren Regeln und Statuten genaue Aussagen zur beruflichen Zugehörigkeit machten. Häufig hatten sie sich zünftisch mit den zahlenmäßig stärkeren Badern zusammengeschlossen. Derartige Verbände boten dem Chirurgen körperschaftliche Sicherheit und schützten ihn vor unliebsamer Konkurrenz, wie sie durch das Therapie-Angebot von Laienärzten, Quacksalbern und umherziehenden Fachvertretern entstand[54]. – Im Gegensatz zur allgemeinen deutschen Entwicklung erfolgte der zünftische Zusammenschluß von Wundärzten in den Niederlanden relativ spät; die meisten Chirurgengilden wurden erst Ausgang des 15. bzw. im 16. Jh. gegründet[55].

Chirurgen wurden schon germanenrechtlich als Gutachter herangezogen[56]. In öffentlichen Ämtern sind sie seit dem Hochmittelalter nachweisbar, wobei unter den von ihnen wahrgenommenen Funktionen Aufgaben des Gesundheitswesens dominieren. Nicht selten übernahmen sie neben den chirurgischen auch internmedizinische Tätigkeiten, was insbesondere dann notwendig wurde, wenn für die Besetzung gebietskörperschaftlicher Stellen keine Akademikerärzte zur Verfügung

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[53] HUIZENGA (1997) [wie Anm. 20], S. 235: „Het volk eiste dus onnodige wreedheid van de kant van de chirurg".

[54] Ahmed MALAK, Drei wundärztliche Niederlassungsankündigungen des 15. Jahrhunderts. Untersuchungen zur Frühgeschichte des medizinischen Werbeformulars in Deutschland, med. Diss. Würzburg 1986; Wolfgang KRAUSE, Wer waren die Patienten des Anonymus Luneburgensis im Juni 1442? med. Diss. Würzburg 1996; vgl. auch Thomas HOLSTE, Der Theriakkrämer. Ein Beitrag zur Frühgeschichte der Arzneimittelwerbung, Pattensen bei Hannover [jetzt Würzburg] 1976 (= Würzburger medizinhistorische Forschungen, 5); M[] A[] VAN ANDEL, Chirurgijns, Vrije Meesters, Beunhazen en Kwakzalvers: De chirurgijnsgilden en de practijk der heelkunde (1400-1800), 2. Aufl. Amsterdam 1946 [recte: 1947] (= Patria. Vaderlandsche cultuurgeschiedenis in monografieën, 24)

[55] HUIZENGA (1997) [wie Anm. 20], S. 235f.

[56] G. KEIL, Verletzungen; DERS., Wunde, Wundbehandlung, in: Reallexikon der germanischen Altertumskunde, begründet von Johannes HOOPS, zweite, völlig neu bearbeitete Aufl., Bd. XXX (2006), hrsg. von Heinrich BECK, Dieter GEUENICH und Heiko STEUER, redig. von Rosemarie MÜLLER, Berlin und New York 2006

standen[57]. In Utrecht beispielsweise lassen sich Chirurgen in stadtärztlicher Anstellung ab 1461 nachweisen[58]. Aber auch ohne eine solche Verbeamtung wurden sie in gebietskörperschaftlichem Auftrag zu öffentlichen Dienstleistungen herangezogen. In Gouda zum Beispiel oblag es einem gewissen Meister Thomaes Hilvertsz, die Kranken und Verletzten im Spital zu behandeln; des weiteren gehörte es zu Hilvertsz' Aufgaben, alle Personen, die zur Aufnahme ins Spital anstanden, vorsorglich zu untersuchen und zu prüfen, ob sie etwa behaftet waren mit „onsuyvere besmettende siecten van leprosie, pocken of andere onsuyvere siecten"[59]. Darüber hinaus waren Chirurgen als Feldärzte gefragt. In Kriegszeiten versorgten sie die kämpfende Truppe, wobei sie sowohl in den Gefechtsformationen wie in der Heereshierarchie ihre festen Positionen zugewiesen bekamen [60]. Das traumatologische Tätigkeitsspektrum derartiger im Sanitätsdienst stehender Chirurgen wird seit dem 14. Jh. in wundärztlichen Feldbüchern detailliert ausgebreitet[61]. Detaillierten Einblick in die feldärztliche Tätigkeit geben auch

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[57] Manfred STRAUBE, „Von der artzenten stat". Ein Kapitel aus der sogenannten Reformatio Sigismundi und das Stadtarztwesen in der ersten Hälfte des 15. Jahrhunderts im Südwesten des Reiches, vornehmlich in Basel, NTM 2 (1965), 5, S. 87-103; HUIZENGA (1997) [wie Anm. 20], S. 236f.

[58] HUIZENGA (1997), S. 236

[59] a.a.O. – „onsuyvere" bzw. „besmettende siecten" waren in ihrem infektiösem Charakter erkannt und galten als ‚ansteckende Krankheiten'.

[60] Ralf VOLLMUTH, Die sanitätsdienstliche Versorgung in den Landsknechtsheeren des Mittelalters und der frühen Neuzeit. Probleme und Lösungsansätze, Würzburg 1991 (= Würzburger medizinhistorische Forschungen, 51)

[61] Gute Beispiele geben die aus Ostdeutschland stammenden Feldbücher, beispielsweise die ‚Wündärznei' Heinrichs von Pfalzpaint und die ‚Prag(-Olmütz)er Wundarznei'; vgl. Claudia RICHTER, Phytopharmaka und Pharmazeutika in Heinrichs von Pfalzpaint ‚Wündärznei' (1460). Untersuchungen zur traumatologischen Pharmakobotanik des Mittelalters, Würzburg 2004 (= Würzburger medizinhistorische Forschungen, 84); Christine BOOT, Die ‚Prager Wundarznei' des 14. Jahrhunderts. Ein traumatologisches Feldbuch aus dem mittelalterlichen Schlesien, med. Habil.schr. Würzburg 1989 [masch.schr. -: die von Hilde-Marie GROSS und G. KEIL besorgte Druckausgabe erscheint 2006 in Stuttgart als Bd. 5 der ‚Schlesischen Forschungen']; Lenka VAŇKOVA, Medizinische Fachprosa aus Mähren: Sprache – Struktur – Edition, Wiesbaden 2004 (= Wissensliteratur im Mittelalter. Schriften des Sonderforschungsbereichs 226 Würzburg/Eichstätt, 40)

archivalische Quellen, wobei hier die Kasuistik des traumatischen Geschehens im Vordergrund steht und oft genug Wundarzt und Verwundeter namentlich genannt werden: „Den 25ten September wordt ghescooten Reiunier Pietersz, soudaet onder cappeteijn Sonnevelt. Dees was met een groot ijser zijn been beneden die kuijt[62] ghescooten, het ghebeent tot mortelen[63] ghebroocken ende zeer deerlijcken ghewondt. Voor dese cuire <ontvieng meester Claes van Zierikzee> 3 pont“[64]. – Ein weiterer öffentlicher Tätigkeitsbereich eröffnete sich für Chirurgen auf forensischem Sektor, wenn es zu Verletzungen[65] gekommen war und das Ausmaß des Körperschadens festgestellt werden mußte. Hier lieferte das Ergebnis der Inspektion, deren Ablauf in Germanenrechten durch ausführliche Vorschriften geregelt war, entscheidende Anhaltspunkte für das Fällen des Urteils. Die urteilsbegründende „wondschouw“ haben die geschworenen Wundärzte vorgenommen, die als „chirurgici iurati“ bezeichnet und als vereidigte medizinische Sachverständige bei den Verfahren hinzugezogen wurden[66]. Beigezogen hat man sie auch bei kirchlichen Prozessen[67], beispielsweise wenn es hinsichtlich Heiligsprechung um das Begutachten von Wunderheilungen ging. Und selbstverständlich wurden die geschworenen Wundärzte auch beauftragt, wenn es galt, jene Blessuren zu heilen, die nach öffentlichem Strafvollzug oder nach „peinlichen“ Befragungen als Körperschäden zurückgeblieben waren. Hier kam die hoheitsrechtlich zuständige Obrigkeit für die Kosten des Kurierens auf; die Höhe des Honorars bemaß sich nach der Anzahl und dem Schweregrad der Verletzungen. Utrechter Stadtrechnungen vermitteln hiervon ein bis in Einzelheiten gehendes Bild[68]:

„Nadat de vrouwen [die beticht waren hekserij te bedrijven] mitten vier gepijnicht waren, heeft meester Aelbert grote gaten in haern eersbillen

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[62] „beneden die kuijt“] ‚im Distalbereich des Unterschenkels', ‚oberhalb des Sprunggelenks'; vgl. Anm. 69

[63] „mortelen“] die ‚Bruchstücke des Mörtelkalks', versinnbildlichen metaphorisch Größe und Konsistenz der Knochenfragmente des Trümmerbruchs.

[64] HUIZENGA (1997) [wie Anm. 20], S. 236

[65] Vgl. KEIL (2005/06) [wie Anm. 56]

[66] HUIZENGA (1997), S. 236f.

[67] HUIZENGA (2003) [wie Anm. 22], S. 210-212

[68] HUIZENGA (1997) [wie Anm. 20], S. 237, zitiert nach M[] A[] VAN ANDEL, De chirurgijn in dienst der justitie, Nederl. Tschr. Geneesk. 76 (1932), II, S. 2224-2228

tot de waeyens toe[69], daghelyx twee mael verbonden over drie weken ende grote onkosten daraen gedaen. 2 gulden 6 st."[70]

Und das gleiche gilt für die spätmittelalterlichen Stadtrechnungen von Aachen[71]:

„Item meister Arnolt der stat meister: van den manne zo heylen, der int sloß 6 wechen gefangen saß ind den der rait dede richten vp den Hoff, hadde waile 25 wonden; 5 gulden videlicet 30 mark".

Nicht nur bei Heeren oder Gebietskörperschaften haben sich Wundärzte verdungen. Spätmittelalterliche Chirurgen standen (nicht anders als die Akademikerärzte) auch in Diensten von Königen und Vertretern des Hochadels. Einer der bekanntesten Vertreter königlicher Leibwundärzte war Heinrich von Mondeville, der Anfang des 14. Jhs. in Diensten Philipps des Schönen stand und dessen unvollendet gebliebenes Lehrbuch früh ins Niederländische übersetzt wurde[72]. Aber auch Grafen nahmen üblicherweise Chirurgen unter Vertrag, so etwa Jan de Blois, der sich 1358 durch den Wundarzt Willem Sonderdanck seine Wunden kurieren ließ[73].

In den Städten war es eine der Hauptaufgaben für angestellte bzw. geschworene Wundärzte, sich der Armen anzunehmen, wofür ihnen jährlich ein bestimmter Betrag ausbezahlt wurde. In Diest durfte der Stadtchirurg auch reiche Patienten behandeln, denen er hohe Honorare in Rechnung stellte. In der Regel erhielten die städtischen Chirurgen einen jährlichen Fixbetrag, der bei besonderen Dienstleistungen – etwa bei der Behandlung von Geistlichen – durch Zuschläge aufgebessert werden konnte. In Kampen ergab sich so für die Periode von 1430 bis 1500 eine Schwankungsbreite, die sich zwischen 16 und 30 Pfunden bewegte[74]. Für ein solches Jahresgehalt mußte der Chirurg dann auch unentgeltlich die kranken Pfründner im Spital behandeln[75]. Bei erhöhtem Therapiebedarf in Pestzeiten erhielten

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[69] ‚von den Nates bis zu den Waden'; vgl. Anm. 62

[70] Wortlaut unter Einbezug des vorausgehenden Rechnungseintrags variiert.

[71] Gerhard EIS und Gundolf KEIL, Nachträge zum Verfasserlexikon [I], Stud. neophilol. 30 (1958), S. 232-250, und 31 (1959), S. 219-242, hier (1958), S. 234f.; vgl. auch VL [wie Anm. 33], I (1978), Sp. 461; EnzMedGesch (2005) [wie Anm. 9], S. 101[a]: Arnold von Aachen

[72] EnzMedGesch (2005), S. 569[a]-570[a]; VL III (1981), Sp. 802-804; HUIZENGA (2003) [wie Anm. 22], S. 126-128

[73] HUIZENGA (1997) [wie Anm. 20], S. 237

[74] a.a.O., S. 237

[75] Caspar Stromayr, für den eine derartige spitälische Verpflichtung nicht bezeugt ist, mußte sich damit begnügen, daß die Reichsstadt Lindau im

geschworene Wundärzte eine Sondervergütung. Auf Patientenbesuche nahmen sie ein Vademecum[76], die gängigsten Arzneimittel[77] und einen Satz der wichtigsten Instrumente[78] mit.

Fürs Spätmittelalter lassen sich in den Niederlanden zahlreiche Chirurgen in städtischen Diensten nachweisen. Die bedeutendsten unter ihnen waren zweifellos Thomaes Scellinck in Namen[79] und Jan Yperman in Ieper[80]. Beide waren im ausgehenden 13. bzw. frühen 14. Jh. tätig; beide

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Bodensee ihm Bürgerrecht und Wohnrecht gewährte, ihn zu unentgeltlichem Behandeln von Armen verpflichtete, ihm ansonsten das freie Praktizieren erlaubte, ihm indessen keinerlei Gehalt zahlte; vgl. PROFF/KEIL (1994) [wie Anm. 30], II, S. 28f.

[76] Ein Taschen- oder Gürtelbuch mit den wichtigsten praxisbezogenen Informationen; vgl. im VL [wie Anm. 33], II (1980), Sp. 1192f., und III (1981), Sp. 397f., die Artikel ‚Genter Aderlaßbüchlein' und ‚Haager Aderlaßbüchlein' und sieh auch Hans HABERNICKEL (Hrsg.), Der Aderlaßabschnitt des Codex palatinus germanicus 558. Quellenkritische und sprachliche Untersuchungen zu einem bairischen „Aderlaßbüchlein" des Spätmittelalters, fil. doctoraalscriptie Nijmegen 1976 [masch.schr.]; Gerrit BAUER (Hrsg.), Das ‚Haager Aderlaßbüchlein' (= Studien zum ärztlichen Vademecum des Mittelalters, I), Pattensen bei Hann. [jetzt: Würzburg] 1978; Gerhard EIS und Wolfram SCHMITT (Hrsgg.), Das Asanger Aderlaß- und Rezeptbüchlein (1516-1531), Stuttgart 1967 (= Veröffentlichungen der Internationalen Gesellschaft für Geschichte der Pharmazie, N.F., 31); G. KEIL, Vademecum, in: EnzMedGesch (2005) [wie Anm. 9], S. 1433. – Vgl. Anm. 12

[77] Johannes Gottfried MAYER (Hrsg.), ‚Anleitungen für einen Wundarzt', in: G. KEIL (Hrsg.), „ein teutsch puech machen" (1993) [wie Anm. 12], S. 443-469, hier S. 452, Kap.

[78] MAYER, a.a.O.; ebenso Kap. 1 der ‚Cyrurgia' des Trierer Wundarztes Johann Schenck von Würzburg, vgl. Werner [Erich] GERABEK, in: VL [wie Anm. 33], VIII (1992), Sp. 637-639, mit Bezug auf: Karl SUDHOFF, Beiträge zur Geschichte der Chirurgie im Mittelalter, I-II, Leipzig 1914-1918 (= Studien zur Geschichte der Medizin, 10-11/12), hier II, S. 561-579, besonders S. 562

[79] = Thomas Schelling van T(h)ienen; vgl. Bernhard Dietrich HAAGE, Th. S. v. T., in: LexMA [wie Anm. 7]; HUIZENGA (2003) [wie Anm. 22], S. 143-150

[80] HUIZENGA (2003), S. 133-143, 146f. u.ö.; HUIZENGA (1997) [wie Anm. 20], S. 153, 165, 168, 173f. u.ö.; TRICOT (1990) [wie Anm. 36]; G. KEIL, J. Y., in: LexMA [wie Anm. 7], IX (1998), Sp. 423f.; Ria JANSEN-SIEBEN, J. Y. [Mskr., Emptine 2000]; G. KEIL, J. Y., in: EnzMedGesch (2005) [wie Anm. 9], S. 1513f.; Roger-A. BLONDEAU, Jan Yperman, ca. 1275-1331, vader van de Vlaamse heelkunde, Ieper/Ypern: Ziekenhuis Jan Yperman 2005

drückten sich ausschließlich „in Dietsche" aus und benutzten das Niederländische als Wissenschaftssprache; beide sind als Lehrbuch-Autoren hervorgetreten und als Verfasser von einem oder zwei umfangreichen Werken bekannt geworden; beide erweisen sich als Kenner des internationalen Fachschrifttums, gelangen aufgrund eigener Erfahrung indessen über den Wissensstand ihrer Quellen hinaus[81]; beide verfügen über ausgezeichnete Lateinkenntnisse, veröffentlichten jedoch ausnahmslos „in de volkstaal". Schelling, der Brabanter, erweist sich gegenüber dem Flamen als zurückhaltender: Nicht allein ist er in der Quellenauswahl konservativer[82] als Yperman[83]; auch beim Behandeln seiner Patienten scheut der Brabanter vor größeren Eingriffen zurück. Schelling vermeidet das Schneiden und greift nur dann zum Skalpell, wenn es unbedingt nötig ist; im Gegensatz zum Flamen entscheidet er sich meist fürs Brenneisen und

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[81] Vgl. Mario TABANELLI (Übers.), Jehan Yperman, padre della chirurgia fiamminga, Florenz 1969 (= Biblioteca della ‚Rivista di storia delle scienze mediche e naturali', 16); DERS. (Übers.), Gli albori della chirurgia nelle Fiandre: il libro del maestro Thomas Scellinck, Florenz 1974 (= Biblioteca della ‚Rivista di storia delle scienze mediche e naturali', 19)

[82] Wolfgang LÖCHEL, Die Zahnmedizin Rogers und der Rogerglossen. Ein Beitrag zur Geschichte der Zahnheilkunde im Hoch- und Spätmittelalter, Pattensen bei Hann. [jetzt: Würzburg] 1976 (= Würzburger medizinhistorische Forschungen, 4), S. 40f.; G. KEIL, Roger Frugardi, in: VL [wie Anm. 33], VIII (1992), Sp. 140-153, hier Sp. 150; Gundolf KEIL und Rolf MÜLLER, Vorläufiges zu Jan Bertrand, in: Fachprosa-Studien. Beiträge zur mittelalterlichen Wissenschafts- und Geistesgeschichte, hrsg. von G. KEIL zusammen mit Peter ASSION, Willem Frans DAEMS und Heinz-Ulrich ROEHL, Berlin 1982, S. 331-345, hier S. 335-338; Bernhard Dietrich HAAGE, Thomas Schelling, in: LExMA [wie Anm. 7], VII (1995), Sp. 1448; DERS., dass., in: EnzMedGesch (2005) [wie Anm. 9], S. 1294

[83] LÖCHEL (1976) [wie Anm. 82], S. 39f., 62f., 248-251 u.ö.; Gundolf KEIL [und Wolfgang LÖCHEL], Gestaltwandel und Zersetzung: Roger-Urtext und Roger-Glosse vom 12. bis ins 16. Jahrhundert, in: Der Kommentar in der Renaissance, hrsg. von August BUCK und Otto HERDING, Bonn und Weinheim 1975 (= Deutsche Forschungsgemeinschaft, Kommission für Humanismusforschung: Mitteilung 1), S. 209-224, hier S. 218f.; Gerhard BAADER und Walter HOFFMANN-AXTHELM, Die Entwicklung der Zahn-, Mund- und Kieferheilkunde im europäischen Mittelalter, Med.hist. J. 6 (1971), S. 113-159, hier S. 144; dazu: KEIL/MÜLLER (1982) [wie Anm. 82], S. 336f.; VL VIII, Sp. 150; HUIZENGA (1997) [wie Anm. 20], S. 174: Einfluß Brunos von Longoburgo; HUIZENGA (2003) [wie Anm. 22], S. 136

begnügt sich beim Kauterisieren mit einem Verfahren, das 1180 zwar durch Roger Frugardi noch ausführlich dargestellt worden war[84], das im 14. Jh. indessen schon wieder sich auf dem Rückzug befand[85]. Auch vor den Ätzmitteln, die Schelling favorisierte und häufig empfahl, wurde im Spätmittelalter gewarnt[86]. Die konservative Vorgehensweise Schellings korreliert schließlich mit seiner geringen Aufmerksamkeit, die er topographischen und morphologischen Gegebenheiten schenkte, und dies zu einer Zeit, wo die Anatomie seit mehreren Jahrzehnten schon bei den Chirurgen zunehmend Beachtung fand.

Erstmals 1281 erwähnt, ist Jan Yperman zweifellos die bedeutendste Gestalt unter den Chirurgen der mittelalterlichen Niederlande. Anläßlich seiner Eheschließung gelobte er am 18. August 1285, daß er sich allen standesbezogenen Verordnungen der städtischen Obrigkeit unterwerfen wolle, und erwarb so als geschworener Wundarzt das Iepersche Bürgerrecht[87]. Im Hinblick auf die Tatsache, daß er 1285 heiratete, wird

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[84] und zwar das Schlußsegment seiner ‚Chirurgie'; vgl. VL VIII, Sp. 142: „ein außerhalb anatomischer Zuordnung stehendes Sondersegment"; vgl. die zahlreichen, komplex geformten Glüheisen im Instrumentenschatz des Chirurgen von der Weser bei STEFAN (1993) [wie Anm. 14]

[85] Friedrun R. HAU, Kauterisation, in: EnzMedGesch (2005) [wie Anm. 9], S. 730; Ralf VOLLMUTH, Traumatologie und Feldchirurgie an der Wende vom Mittelalter zur Neuzeit, exemplarisch dargestellt anhand der ‚Großen Chirurgie' des Walter Hermann Ryff, Stuttgart 2001 (= Sudhoffs Archiv, Beiheft 45), S. 206f.; HUIZENGA (2003) [wie Anm. 22], S. 146

[86] VOLLMUTH (2001) [wie Anm. 85], a.a.O.; Lanfrank von Mailand, ‚Chirurgia parva', XVI/VI, § 11-13; Guy de Chauliac, ‚Chirurgia magna', VII/I, Kap. 3: ‚De cauteriis et formis eorum': „...actio ruptorii ... membris principalibus multum est suspecta"

[87] De „Cyrurgie" van Meester Jan Yperman, naar de handschriften van Brussel, Cambridge en Londen uitg. door E[vert] C[ornelius] VAN LEERSUM, Leiden [1912] (= Bibliotheek van Middelnederlandsche letterkunde, []), S. IVf.; HUIZENGA (2003) [wie Anm. 22], S. 135; BLONDEAU (2005) [wie Anm. 80], S. 182f. mit Zweifel an der personalen Identität; Blondeau plädiert S. 179f. für jüdische Abkunft Ypermans und führt unter seinen Argumenten das Studium zu Paris und den (vorgeblichen) Rückgriff auf antike und arabische Autoren auf: „Zijn vader was eveneens chirurgijn en Jan Yperman had zijn studies in het begin van de 14de eeuw aan de Parijse universiteit [!] voltooid, wat gezien zijn eventuele joodse afkomst een heel normaal verschijnsel was. Het feit dat in zijn ‚Cyrurgie' veel gegevens herinneren aan de Griekse en Arabische wetenschappen, pleit opnieuw voor zijn joodse herkomst"

allgemein [88] angenommen, daß er um 1460 geboren ist. Seine Pariser Studienzeit fällt in die Jahre 1297-1300, wo er von der Stadt viermal den Betrag von 200 „sols parisis" ausbezahlt erhielt[89], mit dem er offensichtlich seine Aufenthaltskosten bestreiten sollte; daß er von Lanfrank [90] unterrichtet [91] wurde, läßt sich durch inhaltliche Korrespon-denzen wahrscheinlich machen und wird darüber hinaus durch Selbstzeugnisse[92] gesichert, von denen das erste die meiste Aufmerksamkeit auf sich gezogen hat: „waerbi ic rade also lancfranc mi riet ende leerde". Es ist also anzunehmen, daß Yperman einen wesentlichen Teil seiner beruflichen Ausbildung beim Pariser Repräsentanten der lombardischen Chirurgenschule erhalten hat. Lanfrank von Mailand unterrichtete in lateinischer Sprache[93]; was das Französische betraf, so machte es dem Flamen ebenfalls keine Mühe, da in Westflandern (und damit auch in Iepern) das Pikardische[94] als Verwaltungssprache diente.

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[88] Mit Ausnahme BLONDEAUS, der sich LEERSUMs Zweifel an der personalen Identität zueigen macht und S. 183f. für ein Geburtsdatum „in de periode 1275-1280" plädiert. Das von VAN LEERSUM beigebrachte Argument, Iepern hätte im 13. Jh. „een paar honderd duizend zielen" gezählt, hat BLONDEAU freilich nicht gelten lassen: Iepern habe zu Lebzeiten unseres Chirurgen „slechts ongeveer 30.000 inwoners" gezählt. Vgl. unten Anm. 96.

[89] HUIZENGA (2003) [wie Anm. 22], S. 135

[90] Gundolf KEIL und Rolf MÜLLER, Deutsche Lanfrank-Übersetzungen des 14. und 15. Jahrhunderts. Zur Wertung der Lanfrank-Zitate in Brunschwigs ‚Chirurgie', in: Medizingeschichte in unserer Zeit. Fschr. Edith Heischkel und Walter Artelt, hrsg. von Hans-Heinz Eulner, Gunter Mann, Gert Preiser, Rolf Winau und Otto Winkelmann, Stuttgart 1971, S. 90-110, hier S. 97; G. KEIL, Lanfrank von Mailand, in: VL [wie Anm. 33], V (1985), Sp. 560-572, hier Sp. 570, mit Bezug auf TABANELLI (1969) [wie Anm. 82], S. 14f.

[91] Die Pariser Unterrichtstätigkeit des Lombarden läßt sich weder der Universität noch dem Kosmas-Kolleg zuordnen; vgl. Eduard SEIDLER, Die Heilkunde des ausgehenden Mittelalters in Paris. Studien zur Struktur der spätscholastischen Medizin, [Stuttgart und] Wiesbaden 1967 (= Sudhoffs Archiv, Beiheft 8), S. 111

[92] VAN LEERSUM (1912) [wie Anm. 87], S. 21[a] und 36[b]; BLONDEAU (2005) [wie Anm. 80], S. 184f.; VL V, Sp. 570

[93] Die Sprache seines Gastlands beherrschte er indessen so gut, daß er bald nach seiner Ankunft in Paris auf Französisch dichten konnte; vgl. SEIDLER, a.a.O. [wie Anm. 91]

[94] Nordfranzösische Mundart mit ausgeprägtem westfränkischem (deutschen) Substrat

Aus den städtischen Rechnungen von 1304 geht hervor, daß Yperman als geschworener Wundarzt angestellt war und daß zu seinen Aufgaben als Stadtchirurg die konsiliarische Versorgung des Belle-Spitals gehörte, das kurz zuvor gegründet worden war: „a maitre Jehan Yperman pour son salair à l'hopital del Belle, quatre livres parisis"[95]. Die Stadt Iepern zählte damals nach dem „Cokerulle"-Aufstand nur noch etwa 20.000 Einwohner[96]. Das del-Belle-ziekenhuis war 1276, vier Jahre vor den Sozialunruhen, durch den Schöffen Jan del Belle gestiftet worden; das frühgotische Gebäude überdauerte unbeschädigt die Jahrhunderte, bis es in den Artilleriegefechten des Ersten Weltkriegs zerschossen[97] wurde.

Zahlreiche Verwandte Ypermans waren in Heil- bzw. Pflegeberufen tätig. Sein Vater soll Wundarzt gewesen sein[98], andere Familienangehörige wirkten im Krankenhausmilieu. Ypermans Mutter und seine Schwester waren beim Liebfrauenspital am Markt[99] angestellt, und auch Ypermans Sohn sollte als Wundarzt die chirurgische Tradition der Sippe weiterführen; das zeigt der Widmungsvermerk seiner ‚Cyrurgie', der zugleich die „dietsche" Abfassung mit unzureichenden Lateinkenntnissen der jüngeren Generation begründet: „hi (nämlich Yperman) maecte dit werck in dietsche om die minne van zyn zoen die zoe ionc was dat hi hem niet wel verstont in gramariën ..."[100]

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[95] VAN LEERSUM (1912) [wie Anm. 87], S. VII; TRICOT (1990) [wie Anm. 36], S. 79

[96] nach 28.000 zur Zeit der Herrschaft des Patriziats im 13. Jh.; vgl. zur Ieperschen Bevölkerungsentwicklung Adriaan VERHULST, Ypern (ndl. Ieper, frz. Ypres), in: LexMA [wie Anm. 7], IX (1998), Sp. 424-427

[97] „totaal verwoest": Bei TRICOT (1990) [wie Anm. 36], S. 78, eine Abbildung der Straßenfront des inzwischen wiedererrichteten stattlichen Gebäudes, zu dessen Geschichte sich BLONDEAU (2005) [wie Anm. 80], S. 31-35, äußert (gleichfalls mit Abbildung)

[98] Vgl. Anm. 87

[99] Het Iepers gasthuis „Notre Dame sur le Marchiet d'Ypres"

[100] Der Yperman-Sohn hatte also die unterste Stufe des Trivialunterrichts (nämlich die „grammatica", die einen in die Schriftlichkeit des Lateinischen einführte) noch nicht durchlaufen. – Vgl. VAN LEERSUM (1912) [wie Anm. 87], S. 5, und sieh Günter BERNT, Artes liberales, in: LexMA, I, Sp. 1058-1061: „Grammatik-" unmittelbar anschließend an den „Elementar-Unterricht"; zu dessen Struktur und Voraussetzungen sieh Erwin RAUNER, in: LexMA [wie Anm. 7], III (1986), Sp. 1799f., und H.-P. Michael FREYER, Das Schulhaus – Entwicklungsetappen im Rahmen der Geschichte des Bauern- und Bürgerhauses

In dem Vierteljahrhundert seines Wirkens für das Belle-Spital genoß Yperman ein hohes Ansehn, was sich auch an seinem Gehalt ablesen läßt: Die krisengeschüttelte Stadt Ieper zahlte ihm für die ärztliche Versorgung der Pfründner zunächst vier Pariser Pfunde, erhöhte dieses Jahresgehalt 1317 auf sechs, 1327 schließlich auf zehn Pfund, was freilich in krassem Gegensatz stand zum Jahresgehalt der in Ieper gleichzeitig wirkenden Akademikerärzte, die seitens der Stadtgemeinde ein mehr als zehnmal höheres Honorar bezogen und als Iepersche Stadtärzte es auf ein Jahreseinkommen von bis zu 80 Pariser Pfunden bringen konnten[101]. Diese Diskrepanz erklärt sich aus dem hohen Renommee der „physici", die weit mehr galten als die handwerklich tätigen „chirurgici"[102], seltener zur Verfügung standen[103] und die möglicherweise auch stärker durch ihre kommunalen Aufgaben gefordert wurden, da sie – nicht anders als geschworene Wundärzte – zur unentgeltlichen Behandlung der Armen verpflichtet waren und (als Internisten tätig) vielleicht auch häufiger gerufen wurden, da innere Erkrankungen möglicherweise häufiger zum Konsultieren eines Arztes führten als die auf dem Gebiet der Chirurgie[104] sich ergebenden Affektionen[105]. Die Stellung der Wundärzte wurde zudem geschwächt durch fortwährende Kompetenzstreitigkeiten mit den Barbieren bzw. Badern[106].

Yperman, der im Gegensatz zu Schelling die beiden konkurrierenden Berufsgruppen unbehelligt läßt und auf Polemiken verzichtet, scheint hin-sichtlich seiner Reputation auch durch Konfliktvermeidung profitiert zu haben. Jedenfalls war sein Ansehen so groß, daß es sich selbst an der Wahl seines Wohnsitzes ablesen läßt: 1310 hatte er ein Haus gekauft, das außerhalb der Mauern in einer jener Vorstädte lag, die vom Niedergang des Tuchhandels geprägt waren[107] und in der

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sowie der Schulhygiene, hrsg. von G. KEIL und Winfried NERDINGER, Passau 1998

[101] TRICOT (1990) [wie Anm. 36], S. 79; HUIZENGA (2003) [wie Anm. 22], S. 135

[102] Vgl. oben S. ■ mit Anm. 22 sowie S. ■ mit Anm. 57

[103] STRAUBE (1965) [wie Anm. 57]

[104] Zum Tätigkeitsspektrum eines Wundarztes sieh oben S. ■

[105] So die Argumentation von TRICOT (1990) [wie Anm. 36], S. 79, der sich HUIZENGA (1997) [wie Anm. 20], S. 238, anschließt; vgl. auch die bemerkenswerten Übersichten bei HUIZENGA (2003) [wie Anm. 22], S. 210-262

[106] Vgl. oben S. ■ und sieh HUIZENGA (2003), S. 227-229

[107] Vgl. oben S. ■ mit Anm. 96

notleidende Weber unter armseligen Bedingungen hausten. Diese Niederlassung außerhalb der Stadtbefestigungen stieß seitens der 13 Schöffen, die entsprechend der Großen Keure von 1165 die Stadt verwalteten, auf Widerspruch, wobei sie einwandten, daß ein geschworener Wundarzt jederzeit verfügbar sein müsse, was indessen nicht gewährleistet sei, wenn er außerhalb der Befestigungen wohne, da die Stadttore bekanntlich nachts geschlossen seien. Um zur Lösung des Problems beizutragen, bewilligte die Stadtverwaltung ab 1313 ihrem Stadtchirurgen einen Mietzuschuß von jährlich zwei Pfunden, was Yperman erlaubte, ganz in der Nähe des Belle-Spitals eine geräumige Wohnung zu erwerben. In dieser neuen Bleibe vermietete er den Schöffen ein Zimmer, das sie als Tagungsraum nutzen konnten, wenn sie in Pflegschaftsangelegenheiten für del Belle zusammentraten[108].

Vor dem Erwerb der innerstädtischen Wohnung hatte sich Yperman bereits als Feldarzt bewährt[109]. 1312 war er mit dem Ieperschen Aufgebot ausgezogen, als die flämische Hansestadt in Kämpfe mit dem Grafen von Flandern verwickelt war. Und 1327 – inzwischen schon betagt[110] - begleitete er die Ieperschen Truppen, als es unter Beteiligung des Hanse-Vororts Brügge erneut zu Auseinandersetzungen mit dem Landesherren [111] gekommen war.

In den Ieperschen Stadtrechnungen ist Yperman zuletzt 1329 und 1330 genannt. Im Jahr 1332 hat seine Aufgaben im Belle-Spital bereits sein Nachfolger[112] übernommen, der allerdings mit einem um 40 % verringerten Jahresgehalt auskommen muß[113]. Die Jahresmiete für das Schöffenzimmer in der geräumigen Wohnung wird 1331 erstmals nicht mehr an Yperman,

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[108] TRICOT (1990) [wie Anm. 36], S. 79

[109] TRICOT, a.a.O.; HUIZENGA (2003) [wie Anm. 22], S. 79; HUIZENGA (2003) [wie Anm. 22], S. 135

[110] Niederländische Chirurgen zeigen eine für das Spätmittelalter bemerkenswerte Langlebigkeit; vgl. die tabellarische Übersicht bei HUIZENGA (2003), S. 259

[111] Ludwig von Crécy, Graf von Flandern. – Yperman empfing für seine Teilnahme als Feldarzt einen Wehrsold von 8 Pfund.

[112] der geschworene Wundarzt Henrik de Bril; HUIZENGA (2003), S. 599[a]: „opvolger van Jan Yperman als stadschirurg"

[113] „a Maistre Henri de Bril pour warder et garir les malades del opital del Belle six livres parisis"; TRICOT (1990) [wie Anm. 36], S. 80; VAN LEERSUM (1912) [wie Anm. 87], S. XII

sondern an seine Erben, die Kinder, ausbezahlt. All das weist darauf hin, daß Yperman am 1. November 1331 nicht mehr am Leben war[114].

„al ... die boeken ..., die zyns [nämlich „des meesters joannis ypermans"] waren ende dair ute dat hi wrochte ... ende dair hi ute zyn werck voldede": Yperman scheint zusätzlich zu den Texten, die ihm in Vorlesungen nahegebracht worden waren – „di hi gehoirt hadde lesen"[115] – eine eigene Bibliothek[116] besessen zu haben, die für ihre Zeit nicht unbedeutend war[117] und sich vorwiegend aus Fachschriften zusammensetzte, und zwar aus lateinischen: Da sie nicht „in dietsche" verfaßt waren, konnte sie Ypermans lateinunkundiger [118] Sohn „niet wael verstaen". Alle Autoren von einschlägiger Bedeutung waren dem „in dienst der stede van yperen" stehenden Wundarzt verfügbar[119]: Neben einer klaren Weiterführung der Roger-Tradition [120] zeigt Ypermans (‚Chirurgie' bzw.) ‚Surgie' starken Einfluß der Salerner, Montpellierschen, Bologneser und auch der sogenannten Französischen Schule, wobei an die Seite Brunos von Longoburgo vor allem der in Paris lehrende Lanfrank von Mailand tritt. Deutliche Spuren haben darüber hinaus das ‚Antidotarium Nicolai' und das ‚Lilium medicinae' Bernhards von Gordon im Lehrbuch des Flamen hinterlassen.

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[114] Der 1. November war der Stichtag für die Jahresmiete, die vom „28 oktober 1830 tot 1 november 1831" berechnet worden war; vgl. BLONDEAU (2005) [wie Anm. 80], S. 191

[115] Proömium der Cambridger Hs., zitiert nach VAN LEERSUM (1912) [wie Anm. 87], S. 5

[116] TRICOT (1990) [wie Anm. 36], S. 80

[117] Zu Buchproduktion und Buchbesitz mittelniederländischer Chirurgen sieh HUIZENGA (2003) [wie Anm. 22], S. 194-200

[118] Vgl. oben Anm. 100

[119] TRICOT, a.a.O., S. 90; Ria JANSEN-SIEBEN, De heelkunde in Vlaanderen tijdens de late middeleeuwen, in: de voetsporen (1990) [wie Anm. 3], S. 67-77, hier S. 72

[120] Aus dem Roger-Komplex hat Yperman einzelne Passagen wortwörtlich übersetzt und versatzstückmäßig seiner ‚Surgie' eingefügt; vgl. die Nachweise bei KEIL/MÜLLER (1982) [wie Anm. 82], S. 337f., mit Verweis auch auf strukturelle Abhängigkeit und dem Vermerk: „Den Zitaten nach kommt die Rogerglosse gleich hinter Lanfrank, und nehmen wir die übrigen Hinweise mit hinzu, so steht der Roger-Komplex mit 28" Zitaten „an der Spitze. Neben Avicenna ist er Ypermans meistzitierte Quelle".

„Het ware oec nuttelic dat die surgijn ware medicijn", sagt Yperman und verweist in diesem Zusammenhang[121] auf die artistische Ausbildung in den trivialen Fächern, wie sie als Grundvoraussetzung für das universitäre Medizinstudium gefordert wurde. Eine solche Doppelausbildung, wie sie bei Bologneser und Pariser Wundärzten begegnet [122] und wie sie der Heidelberger Hof bei kurpfälzischen Wundärzten[123] durchsetzte, schien auch für Thomaes Schelling erstrebenswert gewesen zu sein, denn im Vorwort seines ‚Boecks van surgien' vertritt er die Ansicht: „het dunct my onmogheliic, dat enighe surgien sonder letteren souden moghen begrypen die konste der surginen"[124]. Und dieselbe wissenschaftlich-theoretische Zusatz-Kompetenz verlangt fünfzig Jahre später Hesse, der Jude von Salms[125]: Der im luxemburgischen Vielsalm[126] tätige Judenarzt entwirft kontrastiv das Bild

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[121] ‚Surgie', I, 4, VAN LEERSUM (1912) [wie Anm. 87], S. 12-14, dazu HUIZENGA (2003) [wie Anm. 22], S. 367, 375 u.ö.; ELAUT (1972) [wie Anm. 132], S. 13, mit Bezug auf Kap. VI, 9, der ‚Surgie', VAN LEERSUM, S. 132[b]

[122] Bekannt als Vertreter wundärztlich-leibärztlicher Doppelkompetenz sind Wilhelm von Saliceto, Guy de Chauliac und (mit Einschränkung) auch Heinrich von Mondeville und Lanfrank von Mailand; vgl. VL [wie Anm. 33], III, Sp. 347ff.; 800f.; V, Sp. 560ff.; X, Sp. 1129ff., und sieh auch HUIZENGA (2003), S. 239-247 u.ö.

[123] Vgl. G. KEIL, Heinrich Münsinger, in: VL [wie Anm. 33], VI (1987), Sp. 783-790: „beide Kunste der Erczenie, phisice vnd cyrorgie"; DERS., Peter von Ulm, ebd., VII (1999), Sp. 458-464; DERS., Peter von Ulm der Ältere (und Peter von Ulm der Jüngere), in: Neue deutsche Biographie, hrsg. von der Historischen Kommission bei der Bayerischen Akademie der Wissenschaften, Iff., Berlin 1953f., hier XX (2001), S. 231f.

[124] Het „Boeck van surgien" van meester Thomaes Scellinck van Thienen naar de handschriften van de Koninklijke bibliotheek te 's-Gravenhage en het British Museum te Londen uitgeg. door E[vert] C[ornelis] VAN LEERSUM, Amsterdam 1928 (= Opuscula selecta Ne[d]erlandicorum de arte medica, 7), S. 3[a]; dazu: HUIZENGA (2003) [wie Anm. 22], S. 145 und 375

[125] G. KEIL, Jude von Salms, in: VL [wie Anm. 33], IV (1983), Sp. 889-891, und XI (2004), Sp. 812; Michael E. Graf von MATUSCHKA, Hesse, der Jude von Salms (Solmes), Arzt und Schriftgelehrter. Ein vorwiegend namenkundlicher Exkurs, Würzburger med.hist. Mitt. 8 (1990), S. 207-219

[126] „Vie Salme", „Vielz Salme", „Vielle Saulme", bzw. Salm-Château, Stammsitz der Grafen und späteren Fürsten zu Salm, bzw. Bas-Château, die 1352 zur Stadt erhobene „Vorburg" —: alle drei Ardennen-Orte liegen im heutigen belgisch-luxemburgischen Kreis Bastogne. – In Frage kommen auch

vom ungelehrten ‚Scherer', dem er den akademisch ausgebildeten ‚Meister' gegenüberstellt:
„die scherrer die darr besnident, sie wißent nust von der naturlich kunst[127] vnd zu den schaden das vucht vnd kalt <ist> ader zu eime schaden daß kalt vnd durre ist; ... sy en weßent nust von naturlicher kunst, vnd horet zu jn nust zu kummen wane buren vnd grob volck.

Vnd naturlich meister[128]: sy wirt kunt nach der schryfft vnd nach dem menschen[129], als is genaturt ist, <vnd haben> zu dhune want zu großen herren, daß ir nutz ist vnd jre lon groß"[130].

Um den „surgijn" gleichzeitig zum „medicijn" zu machen und ihm jene Doppelkompetenz aus Empirie und Theorie zu sichern, wie sie Yperman für seine wundärztlichen Kollegen anstrebte, war es sinnvoll, daß der Flame es bei seinem chirurgischen Lehrbuch nicht bewenden ließ und der ‚Surgie' auch noch die ‚Medicine' beigesellte.

Ypermans internmedizinisches Werk, die ‚Medicine', ist mit nur zwei Textzeugen[131] weit weniger stark überliefert als das chirurgische Werk, und man hat über anderthalb Jahrhunderte in ihr nichts anderes sehen wollen „als een aanvulling op het materiaal, dat in de ‚Cyrurgie' werd

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Grafschaft, Burg und Dorf(schaft) Salm im nördlichen Wasgenwald (Vosges) mit dem Hauptort Senones („Saulmez", „Salmez"); vgl. VON MATUSCHKA (1990), S. 213

[127] „naturlich kunst"] ‚die akademische Medizin', gegründet auf die „sex res naturales" und „non naturales" der Humoralpathologie; vgl. Klaus BERGDOLT und G. KEIL, Humoralpathologie, in: LexMA [wie Anm. 6], V (1991), Sp. 211-213; Wolfram SCHMITT, Res naturales [und] Res non naturales, in: ebd. VII (1995), Sp. 750-752; G. KEIL, Humoralpathologie, in: EnzMedGesch (2005) [wie Anm. 9], S. 641ff.; Dietrich VON ENGELHARDT, in: ebd., S. 300[b]; KEIL (1993) [wie Anm. 17]

[128] „naturlich meister"] ‚Akademikerarzt' im Gegensatz zu dem nur „besnidenden scherrer", dem ‚Handwerkschirurgen' oder ‚Wundarzt', vgl. die vorausgehende Anm. und sieh G. KEIL, Physis. Aspekte des antiken Naturbegriffs, in: Natur im Mittelalter. Konzeptionen, Erfahrungen, Wirkungen, hrsg. von Peter DILG, Berlin 2003 (= Akten des 9. Symposiums des Mediävistenverbandes), S. 3-29, hier S. 3f.

[129] „nach der schryfft vnd nach dem menschen"] zielt auf die theoretisch-empirische Doppelkompetenz

[130] Zitiert nach KEIL (1961) [wie Anm. 48], S. 140

[131] Nach der Eisschen Dunkelziffer ist also mit etwa 300 handgeschriebenen Exemplaren zu rechnen, die im Spätmittelalter verfügbar waren.

beschreven“[132]. Strukturanalyse und Quellendekodierung weisen jedoch in eine andere Richtung und lassen erkennen, daß Yperman die ‚Medicine' durchaus als selbständigen Text konzipiert hat, mit dem er seinen Berufskollegen – den zünftisch ausgebildeten Chirurgen – so etwas wie einen internmedizinischen Leitfaden in die Hand geben wollte, der ihnen im Umgang mit den gängigsten inneren Krankheitsbildern die Kompetenz eines Akademikerarztes vermitteln sollte. Er selbst verfügte, als er die ‚Medicine' schrieb, offensichtlich seit langem schon über eine entsprechende internistische Praxis.

Zunächst war es die Makrostruktur, die Ypermans Vorlage für das Abfassen der ‚Medicine' ins Blickfeld rückte[133]; genauere Konturen vermittelte dann die quellenanalytische Dekodierung[134]: Yperman hat die ‚Practica brevis' von Johannes Platearius dem Jüngeren bearbeitet und damit seiner ‚Medicine' einen internistischen Leitfaden zugrunde gelegt, der zu den erfolgreichsten Vertretern der Salerner ‚Practica'-Vertreter gehört[135]. Der

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[132] HUIZENGA (2003) [wie Anm. 22], S. 137, mit Bezug auf L[eon] ELAUT (Hrsg.), De Medicina van Johan Yperman naar het Middelnederlands hs. 15624-41 (14e eeuw) uit de Koninklijke Bibliotheek te Brussel, uitgegeven en van kommentaar vorzien, Gent und Löwen 1972, S. 7: „de *Medicina* <is> de voortzetting van de *Cyrurgie* ...“; vgl. auch W[illy] L[ouis] BRAEKMAN, Fragmenten van Johan Ypermans ‚De Medicina', VMKVA, 1990, S. 2-15; vgl. auch BLONDEAU (2005) [wie Anm. 80], S. 124ff., 166-174

[133] G. KEIL, Jan Yperman, in: LexMA [wie Anm. 6], IX (1998), Sp. 423f.: „Grundlage des humoralpathologisch strukturierten, nach Organ- und Funktionssystemen aufgebauten Lehrbuchs ist die ‚Practica brevis' des jüngeren Platearius. ... Ypermans ‚Boec van medicinen' <holt> auf dem Stand des ‚Breslauer Arzneibuchs' oder des ‚Deutschen salernitanischen Arzneibuchs' Salerner Heilkunde in die Landessprache und <gestaltet> eine Salerner ‚Praktik' im Niederfränkischen nach“.

[134] G. KEIL, „dits die beste raet die icker toe can gegeuen, genomen vte platearise“: Quellenkundliche Anmerkungen zu Ypermans ‚Medicine', in: Geneeskunde in Nederlandse teksten tot 1600, namens der Veste Commissie Medische Historie bei der Koninklijke Academie voor Geneeskunde van België hrsg. von Ria JANSEN-SIEBEN und Herwig DEUMENS, Brussel 2006 (= Academia Regia Belgica Medicinae – Dissertationes, Series Historica, DHS []) [Arbeitstitel; das Symposium fand im Frühjahr 2004 statt]

[135] Zahlreiche Hinweise verdanke ich meinem Würzburger Mitarbeiter Dr. Konrad GOEHL, der eine kritische Edition der ‚Practica brevis' vorbereitet und den Text von Johannes Platearius dem Jüngeren bereits erstellt hat. Das erste therapeutische Segment der ‚Practica' habe ich 2002 bereits (unter Mitwirkung

gegen 1140 abgeschlossene Text verbreitete sich rasch über das gesamte Abendland und war um 1180 schon so angesehn, daß der Zusammensteller der berühmten ‚De aegritudinum curatione'[136] die ‚Practica brevis' als Kompilationsleittext wählte und die Makrostruktur des Platearius-Leitfadens als „rectus ordo tractandi" ganz allgemein für die Gliederung von ‚Practica'-Traktaten empfahl:

„Cum itaque circa corporum egritudines et egritudinum curationes nostra versatur intentio, primum de universalibus eorum [scilicet morborum] curis tractare nos rectus ordo admonet discipline. Morbos autem universales dicimus qui universa solent infestare membra, ut febris, apoplexia, yctericia, et similia. Sed quum febres ex pluribus frequentius causis solent accidi et commoveri, a febribus exordium sumat tractatus"[137].

Wie der Kompilator des ‚De-aegritudinum-curatione'-Kompendiums richtig erkannt hat, ist die ‚Practica brevis' zweigeteilt. Platearius der Jüngere eröffnet seinen Traktat mit den „morbi universales", zu denen er mit dem „febres"-Segment den Auftakt gibt, um ab Kapitel 17 den zweiten Teil seiner ‚Practica' anzuschließen, in dem er über 55 Positionen jene ‚morbi particulares' bringt, die Regionen- oder Organ-Bezug zeigen und die er in anatomischer Folge ‚vom Scheitel bis zur Sohle'[138] aneinanderreiht.

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von Johannes Gottfried MAYER) durch einen Doktoranden vorlegen lassen: Andreas KRICHBAUM, „Practica brevis". Der Kopfteil der ‚Curae' des Johannes Platearius Secundus (Textedition und Textvergleich mit der Edition von Salvatore de Renzi), med. Diss. Würzburg (2002) 2003

[136] ‚Tractatus de aegritudinum curatione', umfangreichstes Werk im Textkorpus des berühmten Breslauer ‚Codex Salernitanus' (vgl. LexMA [wie Anm. 6], II [1983], Sp. 2208), hrsg. von August Wilhelm Eduard Theodor HENSCHEL in: Salvatore DE RENZI, Collectio salernitana, ossia Documenti inediti e trattati de medicina appartenenti alla scuola medica salernitana, raccolti ed illustrati da [Augusto] G[uglielmo] E[duardo] T[eodorico] Henschel, C[arlo] Daremberg e S. de R., I-V, Neapel 1852-1859, Neudruck Bologna 1967 (= Biblioteca di storia della medicina, II, 1-5), hier II, S. 81-386

[137] HENSCHEL, a.a.O., S. 81

[138] = ‚de capite ad calcem': Zur „katà-tópous"-Gliederung sieh G. KEIL, Organisationsformen medizinischen Wissens, in: Wissensorganisierende und wissensvermittelnde Literatur im Mittelalter. Perspektiven ihrer Erforschung, hrsg. von Norbert Richard WOLF, Wiesbaden 1987 (= Wissensliteratur im Mittelalter. Schriften des Sonderforschungsbereichs 226 Würzburg /Eichstätt, 1), S. 221-245, hier S. 230f.

Dieses Gliederungsschema des Salernitaners erschien nicht nur um 1180 als vorbildlich, sondern hat 150 Jahre später auch Jan Yperman überzeugt, der genauso wie der ‚De-aegritudinum-curatione'-Kompilator sich die ‚Practica brevis' als Kompilationsleittext wählte und dabei den salernitanischen Leitfaden teilweise ins Niederländische übertrug. Dabei ist es nicht etwa das Salerner Gliederungssystem gewesen, das Yperman für den Platearius-Text eingenommen hat, obwohl außer Zweifel steht, daß er dessen anatomische Ausrichtung schätzte, was sich schon an der analogen Stoffanordnung seiner ‚Surgie' ablesen läßt [139]. Nein, neben der Makrostruktur müssen es noch andere Beweggründe gewesen sein, die den Flamen veranlaßten, sich für die ‚Practica brevis' zu entscheiden. Die Qualität des Traktats war sicher einer der Gründe –: schon in der Frühphase seines Arbeitens an der ‚Surgie' hat Yperman aus der ‚Practica brevis' geschöpft; darüber hinaus mögen es die Versprechungen gewesen sein, die Johannes Platearius im Prooemium den Lesern seines Leitfadens gibt: er wolle – so sagt er – in seinem Traktat sich „kurz fassen"[140], alle „verborum multiplicitas" vermeiden, sich hüten, die Anfänger mit Wortgepränge zu verwirren, und deshalb wolle er in schlichter Sprache nur das wichtigste mitteilen und sich versagen, die Krankheitsbilder zur Gänze [141] abzuhandeln. Dieses Versprechen bündiger Darstellung und schlichter Beschreibung hat er dann freilich – wie Yperman zornig feststellte – beim Fortgang seiner Abhandlung mehrfach gebrochen.

Yperman hat knapp 60 % der ‚Practica'-Kapitel übernommen, und wenn man diejenigen aussondert, zu denen sich nur punktuelle Übereinstimmungen ergeben, reduziert sich der Bestand auf etwa 50 %. Hinzu kommt, daß Yperman die lateinischen Kapitel meist nur auszugsweise übersetzt; daß er aus anderen Quellen sowie eigener Erfahrung den Text ergänzt; daß er die Abfolge der Segmente gelegentlich variiert und daß er den Text seiner lateinischen Vorlage nicht wortwörtlich, sondern in freier Paraphrase wiedergibt. Und dann läßt sich auch eine wachsende Distanzierung gegenüber Platearius beobachten, die im „riote"-Zwischenfall [142] kulminiert und den Flamen veranlaßt, den Salerner

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[139] Vgl. zur Makrostruktur der ‚Surgie' unten S. ■

[140] „breviter scribere"

[141] „ad unguem"

[142] ‚Practica brevis', Kap. 42 GOEHL [wie Anm. 135] = , Medicine', Kap. 29, ELAUT (1972) [wie Anm. 132], S. 104f., besonders Z. 2777-2780. – Zum Bedeutungshintergrund von „riote" ‚Lächerlichkeit' sieh KEIL (2006) [wie Anm. 134], Fußnote 173

Akademikerarzt der Lächerlichkeit preiszugeben. Ypermans kritische Distanz gegenüber dem Salernitaner ist schließlich so groß, daß der ‚Practica'-Wortlaut gegen Ende der ‚Medicine' zurücktritt und in den letzten Kapiteln von Ypermans Buch andere Quellen in den Vordergrund drängen, die er teilweise schon für seine ‚Surgie' exzerpierte. Am deutlichsten wird dies am „tresoor vanden armen", den ein gewisser „Hermannus [!][143] maecte", aber auch von diesem „Hermannus" alias „Petrus Hispanus" hat sich Yperman letztlich enttäuscht und mit Worten herben Tadelns zurückgezogen[144].

Yperman hat die ‚Medicina' als selbständigen Text konzipiert und als programmatische Schrift vorgelegt. Seine Zielgruppe sind internistisch tätige Ärzte, was neben den „fisiciinen" auch die theoretisch ausgebildeten Wundärzte einbegreift. Mag sein, daß Yperman bevorzugt auf diese Chirurgen doppelter Kompetenz seinen Leitfaden ausgerichtet hat; in der ‚Medicina' spricht er indessen nicht als Chirurg, sondern als erfahrener Internist, was nicht zuletzt in seiner Standeskritik zum Ausdruck kommt, die auf Mißstände in der ‚geneeskunde', nicht in der ‚heelkunde' zielt. Und wenn Yperman auf die fahrenden Heiler schimpft, die unverantwortlich vorgehn und mit „groete worden" ihre Patienten anlocken, wobei sich ihre Versprechungen dann als „logene" erweisen und sie nach mißlungener Kur „diefachtechlike vlien" müssen und „nemmer mer wederkeren", dann richtet sich diese Kritik keineswegs primär gegen chirurgische Empiriker oder laienärztliche Heiler, sondern schilt vor allem wortgewaltige Akademikerärzte, die trotz aussichtsloser Lage ihren Patienten noch „mirabiliter" Heilung versprechen und nicht ohne Gewinnstreben die Hoffnung unheilbar Kranker ausnutzen. Eine solche Haltung ist wenig später seitens der Kirchenrechtler getadelt worden[145].

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[143] verballhornt aus „<Petrus> Hispanus", vgl. dazu KEIL (2006), Fußnote 200, mit Bezug auf den ‚Thesaurus pauperum'

[144] Yperman bezichtigt den Lusitaner der „toverie" und obendrein der Lüge: „Maer ic en gelove niet ane". Vgl. ‚Medicine', Kap. 41, ELAUT (1972) [wie Anm. 132], S. 131, Z. 3720-3731, und sieh KEIL (2006) [wie Anm. 134] mit den Fußnoten 204-226

[145] ‚Decem quaestiones de medicorum statu', Kap. 6: „videtur enim quod medici peccent accipientes stipendium pro infirmitate quam sciunt esse incurabilem"; vgl. Rudolf PEITZ [Hrsg.], Die ‚Decem quaestiones de medicorum statu'. Ein spätmittelalterlicher Dekalog zur ärztlichen Standeskunde, Pattensen bei Hann. [jetzt: Würzburg] 1978 (= Würzburger medizinhistorische Forschungen, 11), S.

Trotz aller Distanziertheit war Yperman von einigen Rezepten des jüngeren Platearius doch so angetan, daß er sie als magistrale Formeln rezipierte, offizineller Gültigkeit für würdig erachtete und sie so gestaltete, daß sie in eine Pharmakopöe oder in ein Apotheker-Manual hätten aufgenommen werden können[146]. Diese Tendenz zur magistralen Formel wirft die Frage auf, ob Yperman nicht doch ein engeres Verhältnis zur pharmakographisch-pharmakopoetischen Literatur hatte, als bisher sichtbar gemacht werden konnte, und ob Cornelius Broeckx tatsächlich „op een dwaalspoor"[147] war, als er Yperman als Übersetzer des ‚Antidotarium Nicolai'[148] ins Auge faßte. Immerhin erweist sich die von Broeckx anvisierte Übertragung als Bestandteil des Brüsseler Yperman-Korpus[149], kommt mit vergleichbarem Kontext im Kompendium eines flämisch-Brabanter Wundarztes [150] vor, entspricht dem pharmazeutischen Übersetzungsstil

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56, und sieh auch Christine BOOT und G. KEIL, in: VL [wie Anm. 33], VII (1989), Sp. 931-934

[146] KEIL (2006) [wie Anm. 134], Fußnoten 160-167

[147] So VAN LEERSUM (1912) [wie Anm. 87], S. XIX; BLONDEAU (2005), S. 160, mit Bezug auf die ‚Sur-gie-' und die ‚Medicine'-Ausgabe von C[orneille] Broeckx, Antwerpen: J. E. Buischmann 1863, bzw. ebd. und beim selben Verleger 1867

[148] Fassung/versie II der mittelniederländischen ‚Antidotarium-Nicolai'-Überstzungen; vgl. HUIZENGA (1997) [wie Anm. 20], S. 154ff., mit Bezug auf Willy BRAEKMAN und G. KEIL, Fünf mittelniederländische Übersetzungen des ‚Antidotarium Nicolai'. Untersuchungen zum pharmazeutischen Fachschrifttum der mittelalterlichen Niederlande, Sudhoffs Archiv 55 (1971), S. 257-300, hier S. 277-286; G. KEIL, Nicolaus Salernitanus, in: VL [wie Anm. 33], VI (1987), Sp. 1134-1151; DERS., Antidotarium Nicolai, in: LexMA [wie Anm. 7], Sp. 708ff., DERS., A.N., in: EnzMedGesch (2005) [wie Anm. 9], S. 70f.; vgl. zur Textgenese auch Francesco J. M. Roberg, Studien zum ‚Antidotarium Nicolai' nach den ältesten Handschriften, Würzburger med.hist. Mitt. 21 (2002), S. 73-129: Entstehung im 12. Jh.

[149] Brussel, Koninklijke Bibliotheek Albert I., „het zogenaamde van Hulthemsche handschrift": Kodex 15624-41; vgl. JANSEN-SIEBEN (1989) [wie Anm. 11], S. 256-260; VANDEWIELE (1965) [wie Anm. 153], II, S. 505-510: Wiederabdruck des berühmten, 1837 von Jan Frans WILLEMS gefertigten Gutachtens

[150] beispielhaft beschrieben und analysiert von HUIZENGA (1997) [wie Anm. 20], zur Ortung und Provenienz: S. 289, 300, 311. Vgl. auch die soeben erschienene Ausgabe: Het Weense arteshandschrift: Hs. Wenen, Österreichische Nationalbibliothek, 2818. Diplomatische editie bezorgd door Erwin

Ypermans[151] und ist – wie noch zu zeigen sein wird[152] – anscheinend in Iepern geschrieben worden. Hinzu kommt der Versatzstücktausch mit dem ‚Liber Avicenne'[153] und dem ‚Jonghen Lanfranc'[154], die beide gleichfalls als Werke Ypermans in Erwägung gezogen wurden[155].

Die ‚Medicine' hat sich als Spätwerk Ypermans herausgestellt[156], was freilich nicht bedeutet, daß sie im Anschluß an die ‚Surgie' geschrieben worden ist. Denn die ‚Surgie' Ypermans – in zwei Fassungen[157] überliefert – ist eigentlich nie fertig geworden, und ihr Entstehungsprozeß hat sich

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HUIZENGA, I-II, Hilversum: Verloren und Constantijn-Huygens-Instituut 2004 (= Middeleeuwse verzamelhandschriften uit de Nederlanden, X, 1-2)

[151] der durch paraphrastische Freiheit gekennzeichnet ist, kontrastiv dazu aber die Kompositions- und Herstellungsvorschriften unübersetzt beibehält; vgl. die beiden bei KEIL (2006) [wie Anm. 134] gegebenen Beispiele mit der Beschreibung des Übersetzungsstils von Fassung II bei BRAEKMAN/KEIL (1971) [wie Anm. 148], S. 277f.

[152] Ich werde demnächst – vermutlich in der Zeitschrift ‚Fachprosaforschung' – auf die Ortung der Fassung II zurückkommen.

[153] De „Liber magistri Avicenne" en de „Herbarijs". Middelnederlandse handschriften uit de XIVe eeuw, uitgegeven en gekommentarieerd door L[eo] J[ules] VANDEWIELE, I-II, Brussel 1965 (= Verhandelingen van de Koninklijke Vlaamse Academie voor Wetenschappen, Letteren en Schone Kunsten van België, Kl. der wetenschappen, XXVII, 83); vgl. zur Einordnung und Quellenbestimmung auch G. KEIL und Rolf MÜLLER, ‚Liber magistri Avicenne', in: VL [wie Anm. 33], V (1985), Sp. 762f., und sieh auch HUIZENGA (1997) [wie Anm. 20], S. 76f. – Zum Versatzstücktausch vgl. BRAEKMAN/KEIL (1971) [wie Anm. 148], S. 283f.; HUIZENGA (2004) [wie Anm. 46], S. 114-116, 125-127; Rolf MÜLLER (Hrsg.), Der ‚Jonghe Lanfranc' (Altdeutsche Lanfranc-Übersetzungen, I), med. Diss. 1968, S. 51-64

[154] BRAEKMAN/KEIL, a.a.O.

[155] MÜLLER (1968) [wie Anm. 153]; ELAUT (1972) [wie Anm. 132], S. 9

[156] KEIL (2006) [wie Anm. 134]; schon ELAUT, a.a.O., S. 10-13, hatte denm internistischen Leitfaden als „vervolgwerk op <de> ‚Cyrurgie'" ausgewiesen und gemeint: „het komt mij voor dat de ‚Medicina' van jongere datum is".

[157] Die eine (1310 begonnene) Fassung bietet den Textkern, der aus sieben Büchern besteht; die andere Fassung bringt zusätzlich (im Anschluß an Buch 7) noch eine ungeordnete Textschleppe, die in der Forschungsliteratur auch als „Buch 8" bezeichnet wird; zumindest die erste der beiden Fassungen kann nicht vor 1328 zum Abschluß gekommen sein; vgl. HUIZENGA (2003) [wie Anm. 22], S. 137-139, 142; VAN LEERSUM (1912), S. XXIV

über zwei Jahrzehnte erstreckt[158]. Freilich lagen wesentliche Teile von ihr schon vor, als Yperman die ‚Medicine' konzipierte; mit ihrer Niederschrift jedenfalls hat er sich nicht so lange befaßt wie mit dem Entwerfen seines chirurgischen Lehrbuchs.

Die Yperman-Forschung „staat nog in de kinderschoenen" und wird, was Text- und Überlieferungsgeschichte betrifft, noch eine Vielzahl von Fragen zu klären haben. Ihre beachtlichen Erfolge, die sie im 19. und 20. Jahrhundert erzielte, lassen indessen schon erkennen, daß die ‚Surgie' von ihrer Qualität und ihrer Wirkung her an der Spitze steht. Aber sie wird flankiert von anderen Werken, die mit ihr in textgenetischem Zusammenhang stehn und von denen bislang nur die ‚Medicine' eindeutig Yperman zugewiesen werden kann. Inwieweit der Flame als Autor oder Übersetzer auch bei den übrigen Texten in Betracht gezogen werden darf, bleibt vorerst offen und muß noch geklärt werden. Die quellenkundliche Dekodierung der ‚Medicine' hat gezeigt, daß zielführende Untersuchungen in solche Fällen[159] zeitraubend und mühsam sind.

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[158] BLONDEAU (2005) [wie Anm. 80], S. 121 und 142, mit Bezug auf VAN LEERSUM (1912) [wie Anm. 87], S. XIIIf., und auf F[erdinand] A[ugustijn] SNELLAERTs ‚Rapport' in den Ann. Soc. méd. de Gand 22 (1854), S. 149-158, sowie auf SNELLAERTs Rezension der Edition von Broeckx [wie Anm. 147] in: ebd. 30 (1863), S. 333-341. – Bereits VAN LEERSUM, S. XXIIIf., konnte sich die Unterschiede zwischen den Fassungen und zwischen den „boeken" der ‚Surgie' nur dadurch erklären, daß er für die ‚Surgie' eine längere Entstehungszeit postulierte und obendrein davon ausging, daß der anfängliche Elan des Autors allmählich geschwunden sei und Yperman die einzelnen Segmente mit unterschiedlicher – will sagen: nachlassender – Intensität bearbeitet hätte: „Wat de overige deelen van het werk betreft, zij opgemerkt dat de stijl van het sevende boek, hetwelk over de ledenmaten handelt [gemeint sind Buch 7 und die Textschleppe (= „Buch 8")], allengs een ander karakter aanneemt en zich kenmerkt door zekere haastigheid in het beschrijven, hetgeen de vraag doet rijzen of het Yperman wellicht aan tijd en gelegenheid ontbroken heeft om zijn arbeid op denzefden breeden grondslag voort te zetten als waarop hij haar heeft aangevangen

[159] Textgenetische Abläufe vergleichbarer Komplexität sind verhältnismäßig selten untersucht worden; vorbildlich analysiert wurden sie für das ‚Haager Aderlaßbüchlein' (BAUER [1978] [wie Anm. 76]), für den ‚Jonghen Lanfranc' (HUIZENGA [2004] [wie Anm. 46]), für das ‚Speyrer Kräuterbuch' und für die altschlesische Materia medica; vgl. Barbara FEHRINGER, Das „Speyerer Kräuterbuch" mit den Heilpflanzen Hildegards von Bingen. Eine Studie zur

Im Hinblick auf die ‚Surgie' hat Carolus Jan Yperman als den „Vater der flämischen Chirurgie" ausgewiesen[160], und die Forschung ist ihm durch Übernahme dieses Ehrentitels gefolgt. Da Yperman aber nicht nur als Wundarzt gewirkt hat, sondern auch als internistischer Autor hervorgetreten ist und als Verfasser zusätzlicher Fachtexte in Betracht kommt, scheint es nicht abwegig davon auszugehn, daß die Wissenschaftsgeschichte in absehbarer Zeit noch einen weiteren Titel für den Flamen bereithält, der etwa lauten könnte: „Vater der niederländischen Fachprosa".

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mittelhochdeutschen „Physica"-Rezeption mit kritischer Ausgabe des Textes, Würzburg 1994 (= Würzburger medizinhistorische Forschungen, Beiheft 2); G. KEIL und Elfriede WÜRL, Die ‚Leipziger Rogerglosse' und die ‚Hübsch Chirurgia' des Niklas von Mumpelier. Eine Konkordanz zu zwei Denkmälern altschlesischer Literatur, Jahrb. schles. Friedrich-Wilhelms-Univ. Breslau 29 (1988), S. 15-71. – Zum zeitlichen Profil derartiger textgenetischer Prozesse sieh Gerhard EIS, Über das Arbeitstempo der mittelhochdeutschen Dichter, Forsch. Fortschr. 36 (1962), S. 16-22, auch in: DERS., Vom Werden altdeutscher Dichtung. Literarhistorische Proportionen, Berlin 1962, S. 58-75. Und zum Arbeitstempo von Kompilatoren spätmittelalterlicher medizinischer Sammelhandschriften sieh Volker ZIMMERMANN, Rezeption und Rolle der Heilkunde in landessprachigen handschriftlichen Kompendien des Spätmittelalters, Stuttgart 1986 (= Ars medica, IV, 2), hier S. 31 zur „Arbeitsdauer" (100 Bll. erfordern 8 bis 18 Monate)

[160] La Chirurgie du maître Jean Ypermans [sic !], le père de la chirurgie flamande (1295-1351 [!]), mise au jour et annotée par m[onsieur] le docteur J[ean-Martin François] Carolus, Annales de la Société de Médecine de Gand 22 (1854), S. 19-148 und 237-295, erschienen unter gleichem Titel im selben Jahr und Ort auch als 196 Seiten starker Sonderdruck; vgl. die Rezension Snellaerts im gleichen Band der ‚Annales' [wie Anm. 158] und die forschungsgeschichtlichen Angaben von BLONDEAU (2005) [wie Anm. 87], S. 73-82

LAUDATIO ETIENNE AERNOUDT

Jan Penning

It is a great honour and pleasure for me to introduce to you em. Prof. dr. ir. Etienne Aernoudt from the Catholic University of Leuven as a Sarton medallist for the academic year 2005 – 2006.

Etienne Aernoudt was born in Roeselare in 1938. In 1962 he graduated as a Metallurgical Engineer. In the same year he also obtained a degree in nuclear engineering.

Etienne Aernoudt started his professional career in 1964 as a responsible for the research about the deformability of metals in the Zwevegem plant of the Bekaert group. For the first two years of his professional career, Etienne Aernoudt was sent to the Rheinisch Westfälische Technische Hochschule (RWTH) in Aachen to perform doctoral research under Prof. H. Stüwe's guidance. In 1966 he obtained his PhD.

In 1967 Etienne Aernoudt was appointed as a part time professor at the Catholic University of Leuven. He became a full professor in 1974 and was charged with courses about Materials Science, Mechanical Metallurgy and History of Technology. He is professor emeritus since 2003.

His research efforts mainly dealt with topics as the deformation behaviour of metals, the recrystallisation behaviour and the texture development in metals, shape memory alloys, high strength deep drawable steels, electrical steels, composite materials and biomedical materials.

Prof. Aernoudt guided twenty doctoral theses and he is author of more than 220 papers. Among them there is a recent book entitled: Materialen maken Geschiedenis (Materials make History).

Prof. Aernoudt undertook different initiatives to improve the collaboration between the Belgian universities, between the Leuven University and developing countries and between university and industry. As such there has been an intensive collaboration between the metallurgical departments of Ghent and Leuven and Sidmar (now member of the Arcelor group) within the Institute for the Encouragement of Scientific Research in the Industry and Agriculture (IWONL). There was also collaboration between the materials science departments of the universities of Ghent, Leuven, and Louvain-la-Neuve and several research groups within the Free

University of Brussels in the framework of the university attraction poles (IUAP) action of the Belgian federal government.

Professor Aernoudt's work was often honoured. He was twice holder of a Francqui chair, among which at the Engineering Faculty of the Ghent University in the academic year 1995-1996.

Prof. Aernoudt was dean of the engineering faculty of the Catholic University of Leuven for six years and chairman of the Department of Metallurgy and Materials Engineering of this university for eight years.

Dear colleague Aernoudt, many times already I had the pleasure to enjoy your big passion for the history of metallurgy and of materials science. On behalf of the University of Ghent, its Engineering Faculty and the Sarton committee, I wish to thank you for the efforts you have been doing to introduce students and many others to the history of materials and to demonstrate how materials improved life of mankind from the very first moment of their use.

THE METAL HINGES OF WESTERN HISTORY

Etienne Aernoudt

INTRODUCTION

Is it not true that the picture we have of human history too often looks like a highway through time consisting of a linear succession of periods of peace and hardships, of victories and devastating failures? Is the attention not too exclusively drawn to the role of kings and warlords, to political systems and religions, to clashes between peoples and nations and to the resulting peace treaties?
The role of technology and technological development in the shaping of the pilgrimage of humanity is often overlooked.
This is especially the case when we consider the very important role played by metallurgy and the processing of metallic materials.

This deficiency can most probably be attributed to the silent paths, the hidden and long hiking trails of human adventure along which technological developments take place, side-tracked from the history highway mentioned above. From the dawn of time till today, these trails pass along places evolving from small village and farm craft centres in the first human settlements, over hidden military and civil workshops in antique cities, through kitchen-size labs in palaces, castles and convents into the inconspicuous places of university, public or industrial research centres of today. In spite of the humbleness of the hiking trail of metals history, curiosity, creativity and craftsmanship –nowadays called "the innovation genes"– have made that class of materials to be the most influential one in history, from the early Neolithicum of 10000 B.C. till the midst of the 20th century[1]!
Indeed, from time to time, the long hiking trails of metallurgical development crossed the highway of political and societal history. It will be

[1] Mike Ashby in "Materials selection in Mechanical Design", Pergamom Press, Oxford 1992

shown by several examples how a new metal or alloy, a new elaborating or working process then fundamentally influenced the wealth of peoples, the outcome of wars, shifted the gravity centres of economic welfare and cultural development. These were the metal hinges along the history of humanity.

THE CHALCOLITHIC HINGE

Metals consist of numerous crystals –called "grains"–, with much simpler crystal structures than stone (silicate a.o.) materials. Some of their atomic planes are densely stacked allowing them to glide over each other like a stack of playing cards. Small stresses can already induce such a glide, since a glide corresponds to the movement of numerous dislocation faults, comparable to the displacement or "glide" of a worm by moving contractions along its length. This is the mechanism of plastic deformation.
During plastic deformation by forging, hammering, etc... the number of "dislocations" increases strongly, up to the point that dislocations on one plane start to hinder the movement of dislocations on other planes. Hence, the flow stress increases, a mechanism which is called "strain hardening". And as a result, metals gain strength by plastic deformation.
Consequently, further deformation becomes more difficult: the second hammer blow needs a greater force than the first one, the third one is even more difficult than the second one... However, by annealing at a sufficiently high temperature (e.g. 600° for copper), the metal can be softened again; it recrystallises into an assembly of completely new grains and the majority of dislocations is annihilated; the "dislocation forest" is cleared so that the original state with low dislocation density is restored; plastic deformation can therefore be continued.

Native copper, like native gold and silver, was known from Palaeolithic times. Even if the red metal was less rare than its more noble native sisters, gold and silver, the regular copper nodule findings in the alluvial basins in the Balkan and the Middle East were not so abundant as to allow its systematic use as a tool material. This explains why this wonderful malleable material was mainly used for ceremonial objects, ornaments and decorations. Nevertheless, although the technology was rather simple –the natural occurring metal did not require smelting or even melting–, we can expect that our far ancestors realised that a couple of blows with a stone hammer strengthened the copper and that property was certainly exploited from time to time to make one or the other tool. They also found out that annealing a

cold hammered piece of copper restored its workability and this allowed them to create ornaments of complex geometry, which were highly valued.

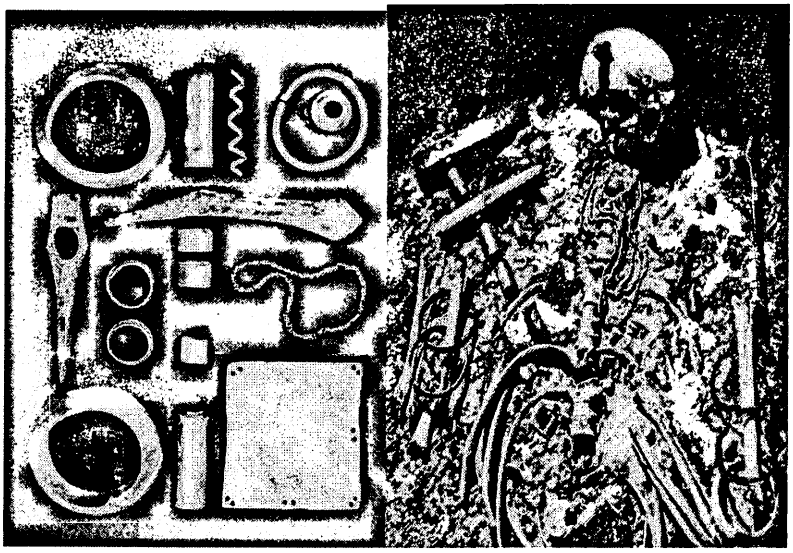

Fig. 1 : Reconstruction of the Varna necropolis tomb nr 4, which most probably belonged to a warlord. He was buried with several golden ornaments and copper axes.[2] *The copper most probably was mined in a nearby quarry*

Theories about where and how the first copper *smelting* technology was developed are still highly speculative. The curiosity of potters being awakened by the regular observation of solidified red copper drops on the walls of pottery ovens when e.g. greenish malachite or blue azurite had been added to the clay in order to colour the vessels, is in many places the most plausible cradle of copper metallurgy. It only needed a –for potters exceptionally high– temperature of 1083°C, sufficient air blow and close contact with the charcoal, in order to transform the copper carbonate –in the case of malachite– into copper oxide, to decompose that oxide and to liquefy the thus obtained copper. Creative and entrepreneurial Neolithic craftsmen then detected which minerals contained the highest copper concentration, and started to "diversify" their pottery shop with a copper smelting one.

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[2] "guide de la préhistoire de Varna"– ed. Archeologisch museum Varna

In the 5th millennium BC, copper-containing mineral deposits were mined in several places. Archaeological evidence of an established trade of colourful minerals amongst Middle Eastern and South-East Asian countries equally exists. This explains why Rutna Glava in Serbia, Varna in Bulgaria (fig. 1), as well as several places in Turquie, Northern Iran and Iraq, and recently also in Corsica and Sardinia[3],[4], all claim to have the historically eldest copper mines and smelting shops.

At the end of the third millennium BC, in Timna, in the southern Negev desert, 30 km north of Eilat, and in several Ouadis between the Nile and the Red Sea, there already existed a well-structured copper mining and copper transformation industry. Smelting took place close to the mines, whereas casting in open one-faced moulds, forging, tooling and tool maintenance shops were found close to the farming regions and in the neighbourhood of the great civil engineering constructions of Pharaonic times. The Egyptians had improved the –imported– copper metallurgy, by adding iron-ore reacting with quartz to form a fayalite slag, thus improving the soundness of the copper metal, from which they made e.g. hammered and polished razors and mirrors[5], needles and knives, chisels and axe heads. In a later stage, when the surface oxide ores were near to exhaustion, they developed the roasting technique which allowed them to extract the metal from underground sulphide ores –like chalcopyrite $CuFeS_2$ - by first transforming the copper sulphide into copper oxide.

The development of copper metallurgy by itself did not have such an important impact on the daily life of people. It did not raise the technological stakes high enough to inaugurate an independent "copper age". The reasons are clear: though the malleability of copper already led to the development of a new set of ornaments, tools and weapons, the Neolithic people were faced with the limitation that as-cast copper is only 200 MPa strong and cold hammered tools barely reach a strength of 400 MPa, which is still far below that of flint and obsidian. Moreover, being a pure metal, the danger of having

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[3] G. Camps "Préhistoire d'une île". Origine de la Corse. Errance. Paris 1988; quoted by J. Briard in "l'Age du Bronze en Europe" [30]

[4] The isle of Cyprus, that was rich in copper and even gave its name to the red metal, does not seem to claim to have the eldest copper mines.

[5] The eldest known copper mirrors stem from the Ancient Empire (around 3000 BC).

entrapped air and gases in the as-cast copper objects[6], seriously deteriorating their properties, always exists.
Therefore, the old stone tools still did the most important jobs. The "lithic" part of the chalcolithic era remained the central element.
The "chalco" part, on the other hand, did have a significant contribution since copper metallurgy definitively opened the metal era. Turning a hard rock into a soft and useful material, which could be cast and recast into a variety of objects with complex geometry, which could be plastically forged and formed into the most beautiful implements, was a unique and irreversible step in human development.

TOOL DIVERSITY AND DEVELOPMENT OF THE HUMAN MIND

Today, when we look at the diversity of metallic objects and structures, which are made by human hands to cope with the physical world, to facilitate social intercourse, to delight our fancy and to create symbols of meaning, we have to conclude that their number supersedes the number of species of flora and fauna created by the natural evolutionary process[7].

The meaning of this diversity is, however, more than just a quantitative one. At the entrance of the "*Musée de l'outil et de la pensée ouvrière*" in Troyes, France, we read a text of the Jesuit father Paul Feller, saying « *l'ouvrage du métier, ne serait-il l'agent du développement de la pensée?* »[8].
What did father Keeler mean?

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[6] Indeed, pure metals have a specific melting point (1084°C in the case of copper). When objects with a complex geometry or different wall thicknesses are cast, the cooling rate can differ from one place to another. As a result, air can be entrapped in so-called "shrink holes" and gases escaping from the solidifying metal can form "blowholes".

[7] George Basalla in "The evolution of technology" – Cambridge History of Science Series – Cambridge University Press 1988

[8] The "Musée de l'outil et de la pensée ouvrière"in Troyes has a collection of many thousands of tools, nicely arranged first according to the nature of the tool (hammers, files, saws, chisels, axes, tongs...) and secondly according to the craft where they are used (smiths, locksmiths, tanners, bricklayers, mechanics, shoemakers, roofers...). The museum also contains a library with more than 30.000 works most of them related to various crafts, but also many books about the history of technology, a.o. a 1572 translation of Vitruvius and an original edition of *l'Encyclopédie* of Diderot et d'Alembert.

When at the end of the last glacial period, humans gradually left a life of hunter-gatherer and started to work the uncovered land, to grow crops and to domesticate animals, the need for appropriate domestic and agricultural tools led to the creation of workshops in the first human settlements. The small variety of stone tools for hunting, for cutting meat into pieces and for transforming animal skin into clothing did not meet the new needs for house building and farming anymore. Settling also stimulated the desire for decoration of houses and diversifying personal dressing-up and last but not least led to more sophisticated religious worship and burial cults.
The arts of felting, spinning and weaving fibres into textiles were developed. The already known art of making ceramic votive figurines from clay was extended and expanded into the art of pottery because food, oil and water now could be stored at home instead of constantly having to be transported in small and light leather bags. And, as already mentioned, out of the art of pottery arose the art of transforming by fire natural raw substance into a new and useful material. A material that, unlike stone tools, could be shaped into the greatest variety of tools and implements, dedicated for every kind of human activity.

From then on, at increasing pace, the pressure of always having to find new solutions for new needs, reinforced by the existential pleasures of creating new processes and new metallic tools, doubtless broadened and deepened people's world of technical thinking. Keelers' words: "l'ouvrage du métier, serait-t-il agent du développement de la pensée." simply mean: "Did tool workshops not accelerate the development of the human mind?"[9].
Unfortunately, that liberation of human imagination not only provided the springboard for almost all progress towards civilisation. All along history it was confirmed that this liberation did not necessarily improve human nature; the development of new materials and tool-making processes simultaneously opened doors for the development of always more destructive devices, an evolution which is erroneously also often presented as "progress". A German poster (fig. 2) that appeared during the First World War expressively

[9] In a mood of cultural optimism, we can attach a similar meaning to the variety of applications developed within the information and communication technology of today.

illustrates this inevitable double face of progress: "Pflug und Waffen, helft Ihr uns schaffen"[10]

fig. 2 : "Pflug und Waffen , helft Ihr uns Schaffen"[10]

NOBLE METAL HINGES IN ANTIQUITY

Egypt was not only a present of the Nile, but also of the Nubian gold

As mentioned, by about 5000 BC men succeeded to smelt copper from gossans formed from oxidized complex ores. Since the melting point of gold (1064°C) is about the same as that of copper (1084°C), it can be reasonably concluded that gold metallurgy –melting and remelting- was developed during the same period, as is illustrated by the joint presence of artefacts of both metals in 4th millennium BC tombs e.g. in Varna, Bulgary (fig.1).
Later on in Egypt, from the early Pharaonic times till the end of the Middle Kingdom, gold mining was an established activity in the desert valleys to the east of the Nile. But the gold reserves were not endless and close to the start of the Middle Kingdom (1550 BC) depletion came in sight. Fortunately, the first rulers of the New Kingdom closed an important alliance with Nubia.

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[10] "Plakate aus dem ersten Weltkrieg" Österreichische Nationalbibliothek, reg.nr. 21537-Dia7, translation: Ploughs and weapons help us to create

This stimulated their metallurgists to develop a process, enabling the extraction of gold from the native "elektrum", a natural gold-silver[11] alloy discovered in Nubia. They sprayed common salt solution on the molten material, thus removing the silver from the melt in the form of gaseous silver-chloride, leaving a bath of nearly pure gold metal[12].
This technology has substantially contributed to the wealth and economic power of the New Kingdom[13]. Alluvial auriferous sand was treated in Nubia[14] (from placer deposits) as well as nuggets from the mines (from "lode" deposits). The latter was called nub-en-set, i.e. 'gold of the mountain', while alluvial gold was named nub-en-mu, i.e. 'gold of the river'. In both cases the noble metal particles obtained were welded together by hammering them into a lump of gold that was subsequently molten, refined and cast into a semi-finished shape.
Archaeologists mention that the gold mines in Nubia and other parts of the Egyptian empire were very efficiently designed and controlled. Although this statement might be true, we should complement it by pointing out the profound disregard for the numerous slaves who were working in the mines. Without that workforce the Egyptian Kingdom would not have lasted so long.

The Lydian Lion: from Barter Trade into Monetary Trade

Elektrum is believed to be the first metallic material from which coins were made. This happened around 650 BC in Lydia under the reign of king Gyges. Elektrum was collected in Sardis from the washings of the Pactolus river. It was in fact much better for coinage than gold mostly because it was harder and more durable. Moreover, techniques for separating gold from elektrum were not widespread in Lydia at that time.

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[11] Elektrum contains between 20 and 30 wt % silver

[12] Accord. to Paul Craddock – British Museum – Journal of Metals Feb. 2001 – the Egyptian gold had a purity between 17 and 23 carad.

[13] Considering that the Egyptian word for gold is nub, the origin of the name Nubia becomes clear.

[14] Auriferous sand was placed in a bag made of a fleece with the woolly side inwards; water was then added and two men vigorously shook the bag. By pouring off the water, the earthy particles were carried away, leaving the heavier particles of gold to adhere to the fleece. This technique does not differ substantially from the one used during the gold rush in 19th century America.

One of the oldest known coins is the "Lydian Lion", shown in fig.3.

Fig. 3: The coin illustrated above is a Lydian third slater, or trite, minted sometime around 600 BC in Lydia[15]

There was, however, one problem. The great variety in elektrum compositions led to a variety in the real metal value of the coins since only the weight of the coin (14 g of elektrum was made into one 'slater' or around one month's pay for a soldier, and smaller fraction coins –e.g. trites– were also produced) and not the exact gold content of the coin was taken into consideration. For this reason, the expansion of monetary payment was slowed down[16]. This however changed rapidly when in Ancient Greece the first pure silver coins came into use.

The Lydian Lion is one extremely important hinge in our history, as it moved societies from barter trade into a much more practical monetary trade. The Lydian coins directly preceded ancient Greek coinage, which through Rome lies at the origin of all Western coinage, and through the Seleukids and Parthians, inspired all Islamic coinage[9-17].

How silver saved Europe

The further eventful role of precious metals in coinage will not be discussed here. Very often, the choice of metal –gold, silver, copper...– and alloy

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[15] S. Karwiese in "The Artemisium Coin Hoard and the First Coins of Ephesus" Revue Belge de numismatique 137 (1991) p.8

[16] "Ancient coins of Lydia" http://www.snible.org/coins/hn/lydia.html

[17] The possible independent introduction of coinage in India and China is still under discussion

composition was closely linked to economic and political trends and turmoil. Its history has been described in numerous numismatic books.
There is however, one very important event in classical Greece, linked to a particular noble metal, which has had a crucial effect on the history of Europe.

It is known that by about 3000 B.C., people in Asia Minor and Crete had learned to smelt silver-lead oxide ores. But the first sophisticated processing of that ore, which allowed the extraction of silver, has been attributed to the Chaldeans in about 2500 B.C. They used a "cupellation" process to win the noble metal from the complex ores[18]. The need for silver (particularly for the flourishing Minoan and later Mycenaean civilisations) resulted in the location and exploitation of lead-silver deposits in what is now Armenia.

After the catastrophic destruction of the Minoan (Cretan) civilisation in 1600 B.C. and the decline of the Mycenaean culture around 1200 B.C., the centre of silver production moved to the mines of Laurion (near Athens), which provided silver for the burgeoning Greek civilisation and significantly expanded the silver trade throughout Asia Minor and North Africa after the 8th century B.C.

The Laurion mines were highly productive. The silver content of the ore was about 1500 gram per tonne[19]. For about 1000 years ending around the 1st century A.C., the Laurion mines were the largest individual source of world silver production (the process is described in fig. 4). But, –remember what was written about the Egyptian gold mines –, we should not forget that at the top of its production (600 B.C. to 300 B.C.), more than 20000 slaves were working in the mines, unfortunates condemned to labour amid the dust and pollution, so that the "democracy" could be rich.

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[18] After smelting in a charcoal furnace, and tapping off the slag, the silver-rich lead is treated in a "cupola", by directing a strong air jet on the surface of the bath. The lead is oxidized, forming a litharge (a lead-oxide dross) at the surface. Porous bone and tile fragments, leaving the silver behind, absorb this dross. This technique is called "cupellation".

[19] Robert Tylecote in "A history of Metallurgy" The Metals Society London 1992

Themistocles (525-460 B.C.) was a leader in that Athenian democracy during the Persian Wars[20]. He may have been fighting with his tribe in the victorious battle of Marathon (490) against Darius and it is told that he deeply envied the glory which Miltiades, the Marathon hero, earned.
At all events, the death of Miltiades left the stage to Themistocles and his main opponent Aristeides. Aristeides belonged to the established educated aristocracy of Athens and was highly esteemed for his honesty and virtue. Themistocles, on the other hand, had a rather obscure education, was notorious for pocketing bribes at any opportunity, but displayed a marked power of analysing a complex situation together with a genius for rapid action.

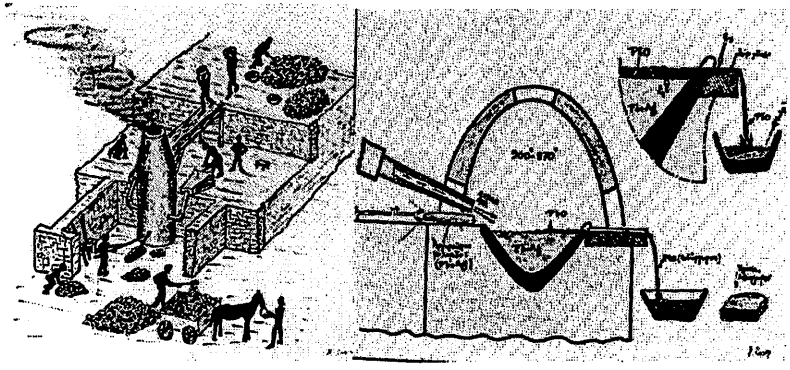

Fig. 4[21]: Work organisation around a lead ore smelting furnace. The furnace is loaded with ore and charcoal from a platform. Air is being pumped through from below. At the lowest level, the molten metal is tapped from the furnace outlet nozzle and transported to the cupellation furnace. The solidified slag is also carried off.
Detailed picture of the cupellation process with overflowing litharge. Sometimes the litharge was also removed by dipping iron rods, chilled in water, into the bath surface and letting the litharge congeal and adhere around the cool tip of the rod. The lead recovered from the litharge was mainly used in civil engineering constructions, e.g. for sealing stone pillars to their sockets.

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[20] "Persian Fire- The first World Empire and the Battle for the West" – Tom Holland – Little,Brown –TimeWarner Book Group UK - 2005
[21] Proceed. "Ancient Technology" – Finnish Institute of Athens – 1987 –ed. Tekniikan Museo Helsinki 1990

Themistocles favoured the expansion of the navy to meet a new Persian threat . He tried to persuade the Athenians to spend the surplus generated by a recently discovered, highly productive silver lode in Laurion, on building such a navy. Aristeides objected, defending the custom to divide the surplus income of the mines among the Athenian people. After months of discussion, now realising that a renewed Persian invasion loomed large at the horizon, the Athenians understood that it was of the highest importance to Athens and to the whole of Greece to accept the proposal of Themistocles to extend their navy with two hundred ships into a total number of around 300 triremes (Greek battleships).

The rivalry between Aristeides and Themistocles terminated in 483 by the expulsion of Aristeides.
Immediately, agents loaded with Laurion silver were sent across the Aegean, buying timber wherever it was available. Themistocles finished the fortification of the natural harbour of Piraeus thereby offering a much better protection than the open harbour of Phalerum. Day and night, the noise of saws and hammers rang in the shipyards of Piraeus and numerous Athenian craftsmen, assisted by unskilled citizens were building the newly-designed triremes at the astonishing rate of two a week.

In order not to create rivalry amongst the Athenian navy admirals, Themistocles diplomatically gave the command of the fleet to Eurybiades, a man of Sparta –though the Greek fleet stayed nominally under control of the Athenian leader–. Hence, the year prior to the invasion of Xerxes, Themistocles was not only the most influential politician in Athens but also in the whole Peloponnesian League. Knowing that the Athenian people were aware of being at the gravest moment of peril in their history, he could persuade them to leave their city undefended for the Persian army and seek refuge in Piraeus. Then came the defeat of the Spartan army at the mountain passes of Thermopylae, followed by the indecisive battle of Artemisium. However, these misfortunes rather strengthened Themistocles' and the Athenians' resoluteness. By a seemingly treacherous message to Xerxes, Themistocles managed to let the Persion armada glide into the narrow straits of Salamis. There, on September 29, 480 B.C., the triremes of Greece inflicted a crushing defeat over the much larger Persian army.

The retirement of the Persians left the Athenians free to restore their ruined city. Athens thus became the finest trade centre in Greece, and induced many foreign businessmen to settle in the city. But what 's even more important :

in the century following the battle of Salamis, arose the great philosophers of classical Greece : Plato, Socrates, Aristoteles, ...

Therefore, after more than two millennia, we can still confirm with great persuasion that lead-silver metallurgy, and more in particular the Silver Mines of Laurion allowed the visionary Themistocles to defeat the mighty Persian invaders, thus saving the cradle of European civilisation[22].

METAL ALLOY AND MIXING HINGES

By deforming metals at ambient temperature, e.g. by hammering or forging, their strength is increased. As mentioned earlier, this is due to the increasing number of dislocations, which act as obstacles to further dislocation movement. Whenever traffic in the city increases, it becomes more difficult to cross the city.

But driving through the city, or gliding over crystal planes, can also be effectively hindered when other obstacles are thrown on the road: these obstacles can be stones or rocks on the road, and foreign atoms or second-phase particles on the slip planes of the metal crystals. As a result, metal alloys are always stronger than pure metals.

When the obstacles are formed by foreign atoms, the hardening effect is called solid solution hardening. It is a strengthening mechanism that prevails in the case of many copper alloys and more in particular in the bronzes. Second-phase hardening only played a minor role in ancient bronzes.

Contrary to pure metals, which have one single melting (or solidification) point, metal alloys have a solidification "interval". They start to solidify at a given temperature, which is lower than that of the pure metal and solidification is completed at still much lower temperature. This allows gases and air to escape more easily during solidification. Hence, casting of complex shapes becomes possible –a.o. by the lost wax process that was developed in Egypt– and work in the casting shop became easier to control.

The important impetus given by bronze to global trade and society organisation

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[22] After the Persian invasion, Themistocles and Aristeides appear to have made up their differences. But Themistocles soon began to lose the confidence of the people. The Spartans further accused him of treasonable intrigues with Persia. He was proclaimed a traitor at Athens and his property was confiscated.

Copper, Gold and Silver are three of the seven metals of Antiquity. The four other metals are Lead (from 3500 B.C.), Tin (from 2700 B.C.), Iron (from 1500 B.C.) and Mercury (from 750 B.C.). No new metallic elements could be extracted till the early second millennium A.C.
Of the four metals mentioned above, only iron succeeded in creating important hinges in technological and human history, as will be shown later on.
Lead and Mercury have their own particular history and –as an element– have certainly put their stamp on the history of technology.
Tin on the other hand, whose applications as an element were of less importance, has played a crucial role as an alloying element for copper in the Bronze Period.

The transition from the chalcolithic period into the bronze period is indeed one of the most important hinges in human history. What is less known however, is that that transition took place in two successive steps.
Rather soon after the establishment of copper smelting metallurgy, it appeared that some copper mines delivered a "copper" with a more yellow tarnish. It was a "copper" from which, compared to copper originating from other mines, sharper knifes and more wear-resistant axes could be hammered –up to a strength of 750 MPa– and from which stronger castings could be made. Analysis of objects and tools made from such material has shown that they were made from copper containing up to 2 wt % of arsenic, an alloying element that strengthens the copper by solid solution hardening.
It can be assumed that the first arsenic-bronzes were accidentally produced since arsenic and copper minerals commonly occur together in sulphide deposits. And as arsenic and arsenic-free copper ores both weather to form greenish oxide and carbonate minerals, it was difficult for our ancestors to distinguish. Modern metal analysis techniques have shown that the first bronzes produced in virtually all of Europe and the Middle East were copper-arsenic alloys, whose composition –including other "impurities" such as iron, antimony, nickel, bismuth, silver..- allowed to identify their mining sites. So, the axe of the famous 5000 year old Neolithic Iceman, whose corpse was found in 1991 in the Austrian-Italian Ötztal, consisted of copper with 0.22% of arsenic and 0.09% of silver. This allowed geologists to conclude that the axle was most probably cast from arsenic containing ores found in the Alps, and not from farther east.
After centuries of experience with the natural arsenic bronzes, metal smelters knew which copper ores allowed to produce the highest quality tools and weapons. In other words, ores with larger concentrations of arsenic were

identified. They then started to mix these with other copper ores and to produce in this way a variety of arsenic bronzes for different applications.

The arsenic bronzes determined the early Bronze Age from 3150 till 2500 B.C. They proved to be the best early copper alloys because of their hardness, their excellent wear resistance and their broad solidification interval. It is clear that for our ancestors, they were not more than "yellow copper"[23], as they did not know about the existence of the element arsenic.

This was no longer the case when the tin-bronzes came on the scene around 2500 B.C., because the smelting metallurgy of tin was already developed nearly 200 years before.

The tin-bronzes started to appear in Mesopotamia[24] during the third millennium B.C. They opened the so-called Middle Bronze Age.
The early smiths who produced the artefacts for the Royal tombs of Ur must have been astonished to find that combining a bit of tin[25], which has a hardness of 5 on the Vickers scale compared to 50 for copper, produced an alloy with a hardness of about 90, that could be raised by hammering to 228 and a strength of 750 MPa, hence twice as strong as hammered copper. Tin bronze thus was comparable to the best copper-arsenic alloys It was even easier to cast and had a corrosion resistance comparable to copper. On top of that, it showed the same workability and wear resistance and a similar attractive colour as its arsenic-containing counterpart.

Tin bronze metallurgy had two more practical advantages over arsenic bronze. First, by eliminating the highly toxic fumes produced when arsenic is roasted, it reduced the mortality of metal-smiths, who were vital members of society. Second, tin-bronze provided more predictable results as it commonly occurs as the oxide mineral cassiterite, which typically contains close to 80 % of tin. Without any knowledge of chemistry, the smiths experienced that is was much simpler to add a well defined quantity of tin metal or –sometimes– to estimate the quantity of cassiterite to add to the copper ore charge than to judge the arsenic content of a mixed oxide or sulphide ore.

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[23] Today, people still give the name "yellow copper" to the well-known brasses which are copper-zinc alloys.
[24] Earlier production might have taken place in the Indian Subcontinent.
[25] They had already made tin- bronzes by mixing cassiterite and copper ores in their furnace.

Tin bronze not only came into use for numerous small ornaments, but also for large statues. It opened the door for a real mass industry of agricultural and other tools, and, of course, of weapons.
However, replacing an arsenical ore with cassiterite was a mixed blessing. On the one hand, extracting tin from cassiterite in a charcoal fire is easy. On the other hand, cassiterite was scarce in the birthplaces of metallurgy and the few placer deposits found there were small, therefore quickly exhausted and soon forgotten[26]. Tin had to be purchased elsewhere.

For the people in the Eastern Mediterranean, the greatest known source of the white metal was situated in Kestel (eastern Turkey), in the Taurus Mountains. The Kestel Mine was in operation during the second half of the third millennium B.C. The ore was taken from Kestel to the nearby city of Goltepe where it was smelted. Since there was no copper at Goltepe, almost all tin was exported elsewhere to be alloyed with copper. Tons of tin were brought by Assyrian caravans to the southern Mesopotamian cities, but also west to the Hittites to get the bronze-work for their weapons and agricultural tools done. For the Assyrians, this deal was very lucrative. After the Assyrian period (1850 B.C.), the tin supply from Goltepe became depleted.

However, towards the end of the second millennium B.C., several new cassiterite sediments started to be mined and gradually, tin-bronze became as important for the civilisations all over Europe[27], as steel is for us today.

Greek and Roman historians[28] have documented later on, how placer cassiterite was transported to the eastern Mediterranean from Tuscany, Spain, Portugal as well as from the Erzgebirge (North-West Tsjechia). There is even a speculation that it was brought overland as tin metal from the Indian subcontinent. Taking the effort that went into mining, smelting and shipping tin into account, its price must have been extremely high.

The development of the Bronze Age in Western Europe deserves special attention. Among the earliest of the Western European metalworkers were

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[26] This might explain why from Egypt to the western Mediterranean, arsenic-bronzes only disappeared from 2000 B.C.
[27] and in fact also in India and China
[28] RICKARD, T.A., 1932. Man and Metals (2 volumes). Whittlesey House (McGraw-Hill), New York, p. 347-349

the Bell-Beaker people, so called for the distinctive bell-shaped clay cups buried with their dead. They were merchants and traders, possibly from Spain, who roamed Europe around 2500 B.C.[29]. They travelled widely, from Poland in the east to the United Kingdom and Ireland in the west, and from the Baltic Sea to the Alps. They were also excellent potters and smiths who knew how to smelt and cast copper, and made knives, spear points, hammers and axes for the people of the territories they crossed. But they did not know bronze yet. Sometime between 2300 B.C. and 1800 B.C., they became assimilated with inhabitants of central Europe, forming a new culture, known as the Uneticians. They are named after a small smelting site beside the village of Unetice (discovered in 1879), situated on the northern outskirts of Prague, about 80 kilometres from the already mentioned, ore-rich Erzgebirge. There, based on the Bell-Beaker metallurgical know-how and thanks to the presence of rich metal deposits in the region, including tin, they gained experience in the production and use of tin bronze. The Uneticians spread throughout the valleys of Germany and the adjoining lands to the west and north. Their bronze ware has been found in graves as far away as England and Sweden[30]. By 1500 B.C., the Uneticians had become rich and were the dominant people of Central and Western Europe[31].

Another panel of West-European bronze history is to be found in the western parts of the British Isles. Archaeological evidence indicates that by about 2000 B.C., metal mining had been, rather independently, developed in Ireland as well as in Cornwall and Devon (England). Most of that early mining activity was directed towards gold and copper. Determining when bronze was produced there is more difficult. As was mentioned, the first tin bronze that appeared in these regions was probably imported by the Uneticians. However, during the Middle Bronze Age, during the so called "Celtic Millennium", the Cornwall-Devon cassiterite mines started to be

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[29] E.G.Garrison in Physics today-online – www.aip.org/pt/vol-54/155-10/p32.html

[30] NIEDERSCHLAG, E., PERNICKA, E., SEIFERT, TH., and BARTELHEIM, M., 2003. The Determination of Lead Isotope Ratios by Multiple Collector ICP-MS: A Case Study of Early Bronze Age Artefacts and Their Possible Relation with Ore Deposits of the Erzgebirge. Archaeometry, University of Oxford, Oxford, p. 61-100.

[31] KNAUTH, P., 1974. The Metalsmiths: The Emergence of Man. Time-Life Books, New York, 160 p.

exploited. Trading relationships were developed for tin and the region played an increasing role as a vital source of tin for the more advanced cultures in the eastern Mediterranean[32-33]. Transport routes developed over land and Phoenicians sea-traders left the Mediterranean for the Atlantic, sailing and rowing for tin in Cornwall.

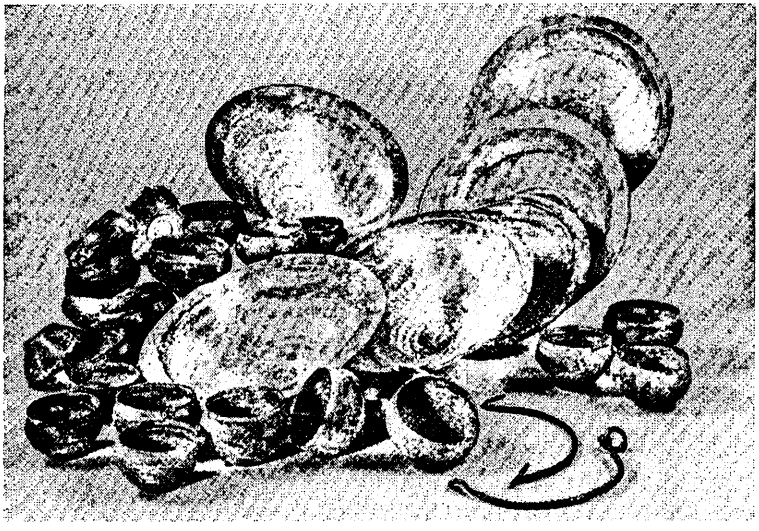

Fig. 5 :Bronze cups, dishes and handles. 8thcy BC. Römisches Museum Augsburg Inv. VF 97 – from the „Ehingen-Burgfeld Bronzefund" [26]

So, from East to West, bronze metallurgy brought important innovations to society. In order to produce bronze, resources of copper and tin were needed. These were dispersed, leading to complex connection and transport networks. Mining regions such as Rio Tinto in Spain, settlements in the Harz, the Erzgebirge and Steiermark, Cornwall and Devon became rich; but also regions that controlled the passage of metal transports, like Tongeren in Belgium and Biberacte in France benefited from the new business. The production of objects soon exceeded the needs of the own region; a distribution economy was created and competition became a rule. This

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[32] Jacques BRIARD " l'Age du Bronze en Europe- Economie et Société 2000-800 avant J.C." –Editions Errance, Paris, 1997

[33] Herbert DANNHEIMER and Rupert GEBHARD "Das Keltische Jahrtausand" Verlag Philipp von Zabern – Mainz - 1993

diversified the demand and created conflicts between neighbours. "Chefferies" arose, characterised by a powerful elite, which controlled, defended and extended territories and which underlined their prestige with ornaments of gold, silver and amber and with numerous bronze arms and implements.

On the scale of the Mediterranean and Europe, because of Bronze, "globalisation" became a reality.

A WORLD WITHOUT STEEL WOULD BE ANOTHER WORLD

Phase and Other Transformations in steel

Iron is one of the metals most abundant in the earth's crust, mainly in the form of various iron oxides.
The metal iron has a melting point of 1537°C. It has the particular property that it changes its crystal structure when being cooled from red heat to a lower temperature. The high temperature phase is called austenite, the low temperature phase is ferrite. In the case of pure iron, the transformation from austenite to ferrite occurs at 910°C.
But 100% pure iron is not easy to make. Then another important property of that metal is the eagerness with which the high temperature phase (austenite) takes carbon in solution. Up to a content of 0.8 wt%, the tiny carbon atoms in the lattice increase the stability of the austenite, causing the transformation temperature to decrease down to 721 °C.

Also the molten iron is happy with more carbon in solution so that the solidification temperature of the material decreases concomitantly.

The low temperature phase (ferrite) of the solid iron has an extremely limited solubility for carbon. Therefore, as soon as the carbon concentration in the austenite exceeds one tenth of a percent, on cooling down and passing the transformation temperature of 721°C, between the already formed ferrite network, an equilibrium second phase mixture becomes visible, usually in the form of tiny lamellae of cementite with composition Fe_3C, separated by ferrite lamellae; that mixture is called pearlite. With increasing carbon content, increasing amounts of pearlite appear until at nearly 0.8% carbon, the whole low-temperature structure has become pearlitic. More carbon hence leads to more pearlite resulting in stronger steel. Up to that composition, the material is called steel and it keeps a good workability.

Beyond 0.8% carbon, separate cementite boundaries start to appear around the pearlite regions. They embrittle the material and so we gradually leave the "steel" region of compositions, approaching the "cast iron" region. There, we observe a further decrease in melting(solidification) point of the material down to 1150°C at a carbon concentration of 4.3% delivering, on transformation, a hard but brittle mixture of cementite and pearlite.

Steels with a carbon content below 1 wt%, have another interesting property. When rapidly cooling them from the austenite region, equilibrium structures cannot be produced, because the mobility of carbon is too low to form the equilibrium phases ferrite and pearlite. Instead, a metastable, distorted ferrite-like structure is formed which bears the name martensite. Martensite is extremely hard and brittle in the as-quenched condition, but becomes tough –without loosing its hardness–, by heating it for a short period at about 250-350°C.

From bronze to iron: victory by necessity

If the origin of copper metallurgy was the result of the curiosity of pottery craftsman, the transition from the Bronze to the Iron Age shows that not curiosity but rather necessity was the mother of invention.
Indeed, for about two millennia, up to about 1200 B.C., the civilisations of the Eastern Mediterranean had satisfied their needs for metal tools and weapons with copper and bronzes. Nevertheless, there is now ample archaeological evidence that around 1200 B.C., iron was already known for a long time as a workable metal. There were obviously good reasons to prefer bronze to iron. The high melting point of iron could not be attained by the early metalworkers and, as will be shown below, compared to copper, a much more complex extraction method had to be used. For the same reason, the thus obtained iron could not be molten and cast. Iron articles hence were individually shaped by forging, which was a more arduous process than casting. An 11% tin bronze could be brought to a tensile strength of almost 800 MPa by hammering whereas the iron available in those times could barely be strain hardened to 700 MPa. And last but not least, bronze had a better corrosion resistance and was so much prettier to look at than rusted iron.
In the second millennium B.C., the Hittites were known to be the best metalworkers of the whole area. They are also recognised to be the first to succeed in extracting iron from iron ore –hematite and magnetite–, by finely intermixing the ore with charcoal, heating it with sufficient blow from

blowpipes and primitive bellows, to 1200°C for a long time thereby reducing the iron oxides to a hot porous iron mass, filled with a viscous iron silicate – or fayalite– slag. The metalworkers thus drew from the furnace a mass of spongy iron, reheated it in a forge and literally squeezed out the slag by hammering. The thus obtained bloom consisted of a rather low-carbon iron that in many cases still contained entrapped stringers of slag. Careful control of the furnace operation was needed in order to prevent too long contact times between the iron and the charcoal, which could lead to an excess carbon in the metal, making it as brittle as glass. The efficiency of the first primitive furnaces was very low, as archaeological estimations tell that 500 kg of charcoal was needed to produce 100 kg of metal, and only 50% of the iron content of the ore was reduced to metal.

There was thus no technical reason to start an Iron Age, if not late in the second millennium B.C., invaders from the so-called "Peoples of the Sea" led to the collapse of a number of empires including that of the Hittites. As a consequence, bronze became scarce as the supply of tin and even of copper to the bronze smelters of the Eastern Mediterranean was suddenly interrupted.

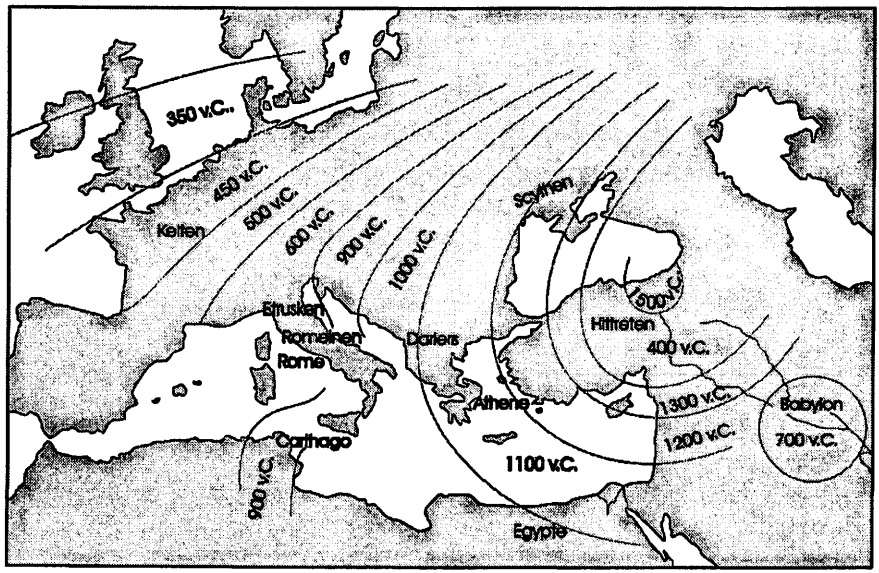

Fig.6 : Chronology of the spread of iron metallurgy from its origin in Anatolia 1500 B.C.

From then on we see a rapid rise of iron as a substitute for copper and bronze objects, even when after 900 B.C., tin became available again and bronze remained in use e.g. for the breastplates and helmets of the Greek soldiers during the Persian wars. The ironmasters of the time had by then learned to control hardness and strength of the iron they made, by carefully looking at colour changes of the flames and the time of heating –They did not yet know about the carbon content, nor about the amount of pearlite in the material–.

Steel created and destroyed empires

The sponge iron process described above has remained the unique iron-making technology from then on till the late Middle Ages. As iron ore was abundant everywhere, the technology spread east- and westwards–see fig.6-. It had a great impact on agriculture and civil engineering –fig.7-, and still more on the military history of the last millennium B.C. In the long Persian wars, Greek soldiers indeed had bronze breastplates but iron daggers and spears. And for the conquest of Palestine by the Babylonians, for the Phoenician-Carthagenian colonisation of Spain, for the journeys of the same Phoenicians to England, for the Phalanxes of Philip II and Alexander the Great, for the Roman legions in the Punic wars, huge amounts of wrought iron were required. Estimations tell that 20 to 30 tons of iron metal was needed for a well-armed Roman legion. From those times, remnants of numerous low-furnace bloomeries were found all over Europe, to such an extent that around 1900 A.C. the blast furnaces of Katovice in Poland were still partly charged by nearly 2000 year old slag heaps from the nearby region.

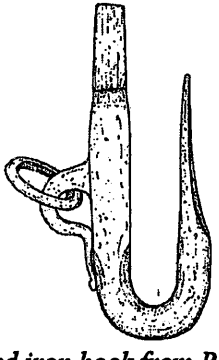

Fig.7: Forged iron hook from Roman times[34]

However, the use of iron for high-quality arms and tools would not have been possible without the development of steel hardening. From the beginning of the 10th century B.C., blacksmiths were intentionally hardening high-carbon steel by quenching it from the austenite region, transforming it into martensite and slightly reheating it (the so-called "tempering" process) for restoring its toughness.
Somewhat later, the process of surface carburising low-carbon steel after which it was quenched and tempered, was invented. As a result, tools and weaponry that combined high tenacity and hardness could be made.

A passage in the Odysseus describing him and his men being trapped in the cave of Polyphemus, the one-eyed giant, describes how they decide to try to get the giant drunk and blind him by snatching a burning olive trunk out of a fire and thrusting it into his eye "As when a man who works as a blacksmith plunges into cold water a great axe which hisses aloud... since this is the way steel is made strong, even so, Cyclop's eye sizzled about the beam of the olive."[35].
Again, our ancestors did not know what was really happening in the material. It has even been told that carburising steel implements before hardening them, was considered to be a purifying rather than an alloying process.

Preparing the industrial revolution: the birth of capitalism
After the fall of the last Roman Emperor, Roman Augustulus, in 476 A.C., mood and capital were lacking to revive the exhausted economy. Because of the scarcity of gold and silver for currency, large portions of Europe were forced into a barter economy and slipped into obscurity. For the next thousand years, tools and weapons were made with the same materials and the same technology as in Roman times.

The Roman iron furnaces were already improved versions of the primitive furnaces used in the old Mediterranean empires. They were able to increase the production per run from 5 to 25 kg. But even if their furnaces were

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[34] Marc Lodewijckx et al. in "A 3th century collection of a Roman villa" in Acta Archaeologica Lovaniensia 33, (1994)
[35] "How the Iron Age began" R. Maddin, J.D. Muhly, T.S. Wheeler – Scientific American pp 122-131

somewhat larger in height than in the past, they were still working as "bloomeries", making sponge iron, and blown by bellows activated by human power.
Towards the end of the first Millennium, while the rest of Europe still stagnated, ironworkers in Catalunia, Spain, managed to improve furnace technology –probably stimulated first by the Visigoths and later by the Moor occupants–. They developed a hand-blown new design of smelter –known as the Catalan furnace–, enabling them to produce 175 kg of iron per run. Further increases in capacity were realised by smelters in Austria, who developed the "Stückofen" which was three or more meters high, nearly twice as tall as the Catalan furnace.

But the most striking novelty at that time was the use of watermills to drive the bellows, thereby being able to generate blasts that reached the top of the furnaces.
The large quantities of ore and charcoal needed from this moment on, demanded for mechanical devices to drain mines, to crush ore and to forge hot iron. Waterpower that had been used since several centuries for grinding corn and for winnowing felt, now became the basic instrument for large-scale mechanisation all over Europe. Waterpower was therefore one of the keys of Europe's emergence from the Dark Ages.

Monasteries were extensively involved in the construction of watermills for all kinds of purposes. Later, they were followed by princes and kings who owned several mining sites. In order to install the infrastructure needed for their operations, both mine-owners and ironmasters required substantial amounts of capital. New institutions and new methods arose to finance these large-scale projects, and with these came the birth of capitalism. Rich German and Italian families took the lead in developing the European banking system.

Preparing the industrial revolution: the two-stage steel making process
The furnaces became taller and the air blasts more powerful. Therefore, the ore was exposed to charcoal at higher temperatures and for longer times. Here and there, iron masters started to notice liquid iron to flow to the bottom of their furnace. Although at first, the liquid iron presented a problem to the smelter, it did not take long before creative ironmasters started to tap this iron and noticed that it could be cast in moulds: they had produced cast iron with a carbon content of 3 to over 4 wt%, with a melting point as low as

1150 °C. In the German-speaking part of Europe metallurgists spoke about the "Flussofen" as opposed to the "Stückofen".
The material was very brittle, but, living in a time with increased technical and market opportunities, compared to centuries before, they started to appreciate the value of the previously undesired cast iron for use first in church bells and hearth plates, and later in cannons[36] and cannonballs – gunpowder having been introduced in Europe around 1300 B.C.–. The new market that had emerged led them to make a new furnace design, where ore and charcoal were charged at the top, after which they slowly sank downwards, reacting with each other to produce liquid cast iron –or better "pig" iron because of numerous impurities still present– reaching the bottom leaving a lighter liquid slag layer above the metal melt. Liquid iron and slag could subsequently be tapped.
The predecessor of the modern blast furnace was born around 1400 A.C., according to metal archaeologists "somewhere in the Rhine provinces with the French, Belgians and Germans probably sharing honours in this great technological triumph"[37]. However, the first blast furnaces were not very reliable because of irregularities in their functioning: there was no certainty whatsoever that every production run would be successful and yield molten iron. They moreover consumed a disproportionate amount of fuel. This might explain why Steiermark in Austria, which produced very high quality iron, did not use a blast furnace until the 18th century.

The reasons are obvious: the majority of applications still required wrought steel, made by the traditional blooming process.

And it is here that the metalworkers of the Liège region came into play. They were known to be excellent craftsmen, able to make knives and nails from "fer, plus fort que le fer!"[38]. Already in the early second millennium, they built furnaces of 100 kg of iron per run, later followed by "Stückofen" type furnaces which produced about 700 kg per run. Moreover, they were amongst the first to use watermills for powering bellows and hammers. They managed to let their "forges" work continuously, even in dry seasons, by building water reservoirs in the vicinity of the furnaces. On top op that, they had a good knowledge of the variety of steel qualities, using Lorraine ores

[36] Far into the 17th century gun barrels were made of bronze.
[37] D.A. Fisher in ""The Epic of Steel" – Ed Harpe and Row NY – (1963) – see also : http://www davistownmuseum.org
[38] Iron, stronger than iron

for common items –of lower quality because of higher phosphor content–, but preferred the more expensive –low phosphorous- iron from Northern Spain for the highest quality knives and nails.
They also had several high furnaces, built in the Liège region, producing cast iron for applications such as stoves, hearth plates, architectural ornaments...

It was in that same region of Wallony that towards the end of the sixteenth century the development took place of what was soon called "the Walloon Furnace". It was a technology that transformed the carbon-rich and often impure cast iron from the blast furnace into a high-quality, low carbon wrought steel. Cast pigs from the blast furnace where progressively re-molten in a hot oxidising flame that removed carbon and impurities from the falling droplets. The purified iron droplets fell through the fayalite (FeO.SiO2) slag layer and solidified on the bottom of the so-called "affinerie" or "finery" furnace. The thus produced iron bar was then reheated in the "chaufferie" or "chefery" in order to prepare it for forging.

The production of wrought steel in two successive stages was a precursor of modern steel making, which is still used in more than 90 % of the steel industry today. It is therefore justified to call the development of the Walloon furnace a "proto-industrial revolution".

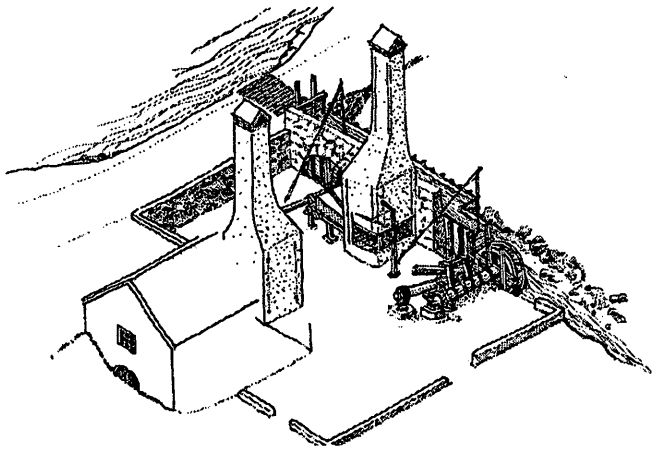

Fig.8: *Drawing of a Walloon type furnace and forge from Österbybruk, Sweden. At the left the finery (the bellows at the backside are not visible), at the right, next to the river, the chaufferie and the hammer*[33]

This new technology was introduced all over Europe, and accelerated the development of the steel industry in Great Britain and even more in Sweden. Indeed, up to the sixteenth century, mining and metallurgical industries were generally more advanced on the continent than in Britain. With the extension of the Commonwealth, however, the demand for iron increased dramatically, driven in part by the appetite of the shipbuilders for anchors and rivets and of military for firearms and cannons.[39].
England then, eager to become self reliant in the production of steel, recruited a substantial number of Walloon ironworkers, who brought the Walloon process with them, thus speeding up the development of the British steel industry.

The contribution of Walloon ironmasters to the Swedish steel industry is considered to be even more important, to the extent that some Walloon historians see in their fellow countryman, Mathieu de Geer, who organised the emigration of the Walloon metalworkers to Sweden, "the Father of the Swedish industry"[40].
Several conflicts in Europe during the 16th and 17th century severely hit the Walloon iron industry, creating a socio-economical crisis in the region. Between 1620 and 1640, about five thousand people accepted the invitation of Louis de Geer, uncle of Mathieu, to join the Walloon families that had already left the Low Countries for religious reasons. Louis de Geer had lived in Sweden from around the turn of the century and had become the owner of several ironworks –moreover, wealthy as he was, he became the banker of King Gustav-Adolph II–. He understood that in order to further develop the iron industry in Sweden he needed to import qualified personnel from abroad and it is that what his nephew Mathieu arranged for him. Most of the Walloon families settled in the region of the Dannemora mine, close to Uppsala, which was known to have the most abundant, but also the best, iron ore in Europe. They implemented the Walloon technology –fig. 8-, mastered to the extent that it allowed producing numerous variants of steel. Some of

[39] Despite laws passed by Elisabeth I, limiting the export of cannons. The British trade was so lucrative that smugglers managed to export large numbers to Spain. When the Spanish Armada weighed anchor to invade Britain in 1588, the majority of its guns were returning to the place were they had been manufactured.
[40] "Sur la trace des Wallons de Suède" Ph. BASTIN – in « Terre de Durbuy » 2003

these variants were regarded as professional secrets, not to be divulged, not even to the learned experts of Jernkontoret (The Swedish Association of Ironsmiths). Two centuries later, Christopher Polhem, one of the great Swedish technicians of that age, was almost a fanatic in supporting the Walloon iron when he wrote "all other bar iron anywhere in the whole kingdom ... is as good as useless and to be rejected on account of the infidelity and deceptions of its art"[41].

It has been assumed that Sweden was exporting about 4000 ton of iron before the first Walloon furnaces were installed. Already in 1650, 18000 ton was reached. Then, by the 1740's, the average export had risen to 42000 ton. Nearly half of that amount, mostly in the form of bars, was absorbed by Britain. In the midst of the 18th century, Sweden had indeed become Europe's largest exporter, thus representing a substantial share of the international trade.

It goes without saying that the expertise brought into Sweden by the Walloon immigrants has given a historical impetus to the Swedish steel industry. The immigrants have integrated very well in Swedish society and the nearly fifty thousand descendents of today are proud of their origin. About two thousand of them belong to the "Vallonättlingen", –descendents of the Walloons of Sweden– a society that has the objective to keep the memory of the contribution of their ancestors to the Swedish economy alive.

Making the industrial revolution possible: from charcoal to coke

Already during the 1760's, Russian imports of steel in Britain reached the Swedish level. Several researchers stress that the reason for the stagnation of the British home industry was the menacing deforestation of Britain, because of the immense quantities of charcoal fuel consumed. Between 1588 and 1630, the cost of charcoal indeed increased from being one half to nearly three quarters the cost of smelting iron. The state of the British forests thus had become an obstacle to the British iron expansion and the country was obliged to turn to younger and hitherto less affected economies[42].

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[41] "Swedish Iron in the 17th and 18th Centuries-Export Industry before the Industrial revolution." Karl-Gustaf Hildebrand – Jernkontoret Berghistoriska Skriftserie 29 - 1992

[42] Some British scholars in economic history stress that it was not the shortage of charcoal, but standing concerns about labour cost –because of the large amount of work-hours that went into charcoal burning– that made steel, from the economically less-developed Sweden, cheaper than the British steel.

In every case, by the start of the eighteen century, the price of imported steel increased and the situation worsened.

First trials to use coal instead of charcoal for the production of pig iron, had already been performed in the early 17th century. These tests were, however, not successful because the sulphur content, coming from the coal, in the so-produced iron was too large, hence causing brittleness[43].
Decades later, a certain Abraham Darby, son of a Quaker family of farmers in Worcester-shire had not only learned the art of forging in his fathers' workshop, but also the art of making coke. Neighbouring brew-masters indeed used coke for drying malt, since the use of coal during this drying process, caused the beer to absorb evaporating gases, which resulted in an unpleasant taste. The entrepreneurial Darby, who was aware of the increasing problems of the iron industry in his country, came to the conclusion that coke should enable a new future for the iron industry. He leased ironworks at Coalbrookdale near the Severn River. The first coal roasting trials did not result in the best quality coke, but fortunately the coal mined in that region was of low sulphur content. In 1709 he made the first successful production run, not yet aware that he had made a most important contribution to the first industrial revolution that would follow.
Then, in spite of Darby's success, the use of coke was for a long time only marginally accepted as a substitute for charcoal.
But the Darby family remained self-confident and markedly innovative. Darby's son, Abraham II, cooperated closely with the developers of the atmospheric engine (Thomas Newcomen) and the steam engine (James Watt) for whom he produced cast iron boilers. These were used to pump water from the coalmines. Inspired by this application, Abraham II decided to use a steam engine to pump water to a reservoir at a higher level, allowing his furnace to operate continuously. In 1755/56, he built two new furnaces with direct powering of the bellows by steam engines. He thereby succeeded in making pig iron of an extremely good quality, that could be refined in an adapted version of the Walloon furnace into wrought steel.
In 1779, Abraham III, continuing Darby's steel tradition, then built the famous Ironbridge over the Severn with 25-meter long rib castings, demonstrating that iron could be used for large structures. And the subsequent descendents of Darby continued to operate the Coalbrookdale foundry until well into the twentieth century.

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[43] Sulphur atoms migrate to the grain boundaries and this leads to inter-granular fracture on subsequent hammering or forging.

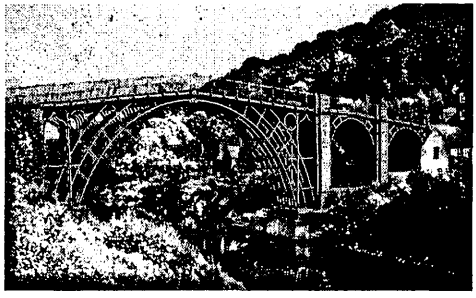

Fig.9: The Ironbridge in Coalbrookdale (1779) over the Severn river.

Towards the end of the 18th century, several ironworks in Wales, England and Scotland had already adopted Darby's technology. Most of them were small to medium-size initiatives that did not require great amounts of capital, but gave in all cases a great autonomy to the region. In 1800 the English ironworks already produced 100.000 ton, five times as much iron as the European continent; in 1850 –two years before the first coke-fuelled blast furnace was put in operation in Müllheim, Germany– the production amounted to 900.000 ton, still ten times that of Germany. And at the dawn of the First World War, England produced nearly 10 million tons of steel ... but in that same year Kaiser Wilhelm's Germany had already made up arrears!

Further developments in the iron- and steel industry were without doubt of equal importance. These include the transition of the Walloon finery to transform pig iron into steel into the puddling technologies and further into the Bessemer and Thomas blowing processes and the introduction of the use of preheated air in the blast furnace. And last but not least Europe saw the development of the Henry Cort roll forging process, a predecessor of the rolling mills, which have evolved into indispensable production equipment of automobile steel sheet.

But the metallurgical hinge of greatest historical importance, is without doubt the substitution of charcoal by coke for making iron, and the demonstration that the iron obtained in this manner could be used for machines, train rails, large engineering constructions, and a completely new steel architecture, thereby completely changing the landscape and the society of 19th century Europe. Unfortunately, new societal problems were equally

created: an oppressed workers class was developing, and new inequalities appeared all over Europe. They led to revolt and rebellion all over the continent. It was the most negative aftermath of the first industrial revolution, too often forgotten to mention when describing the technological – and in the long term of course general prosperity creating- jump that was made.

ALUMINIUM MADE MODERN AIR TRANSPORT POSSIBLE

Precipitation hardening
In several alloys, the solubility of alloying elements in the base metal matrix is limited and beyond a given concentration, a second phase is formed. However, the solubility often increases with increasing temperature. When such an alloy is quenched from a high temperature, a supersaturated solid solution is obtained because of the small mobility of atoms at low temperature. When holding the quenched material for some time at room temperature or –often more practical– at a slightly increased temperature, the material evolves into its equilibrium two-phase state by precipitating small particles of that second phase. The smaller those particles are, the more they hinder dislocation movement, and hence, the stronger the material. This mechanism is called precipitation hardening. The position achieved by precipitation hardening alloys in our modern economy is significant. The leading example of it is doubtless that of the precipitation hardened aluminium alloys.

In 1782, Antoine Lavoisier had prophesied that "metals" should be present in the so-called "earths" –lime, magnesia...– but the means to detect them were not available in his time. It was left to Sir Humphrey Davy to separate several alkali metals from their oxides. He had learned about Volta's "voltaic pile", and set out to use such a pile to decompose various chemical compounds back to their component elements. With this technique, Davy could extract sodium, potassium, magnesium from their molten hydroxides and chlorides, but he was unable to extract the metal hidden in alumina (Al_2O_3).
It was a Danish scientist, H.C. Oersted who could extract the first drops of aluminium from aluminium salts in 1825. But Oersted did not attach great importance to this new metal, nor did Friedrich Woehler who succeeded in producing somewhat larger drops. Finally, it was Henry Sainte-Claire Deville who developed an extraction process independently, that delivered sufficient quantities of aluminium to impress the visitors at the 1855 Paris

exhibition and not in the least the Emperor Napoleon III. The latter asked to meet him to share his views on the use of the new light metal for knots and breastplates for the Army and for spoons and forks for State Banquets.
However, since the new metal was as expensive as silver, only some small-scale applications –jewellery and artistic works like the Diane de Gables in the Louvre, and the cap of the Washington monument (1884)– existed at that time. Large-scale applications had to await the electrolytic process that began to supersede Deville's in the 1890's.
Oersted's and Deville's extraction processes indeed demanded electric batteries and large amounts of other metals, namely sodium or potassium. But as soon as an inexpensive source of electricity became available, thanks to the development of the electric generator, Charles Hall[44] and Paul Héroult developed an electrolysis cell in which alumina was dissolved in molten cryolite and electricity was provided from a nearby power plant. Circumventing the need for costly batteries to reduce the aluminium-oxide, the price of aluminium was reduced from 15 $/kg to only 1 $/kg. However, the fabrication of aluminium still remained too costly until the Austrian Karl Bayer developed a process to transform the bauxite ore –which contains aluminium-silicates– into alumina.

Thus, humanity had to wait nearly two millennia after Metal Antiquity before one of the most abundant metals in the earth's crust could be extracted from its ore.
Our ancestors indeed did not know that the reactivity of elements or the stability of their oxides increases from silver to copper, from copper to iron and very dramatically from iron to aluminium. The more stable the oxide, the more difficult it becomes to extract the metal.

The potential for the mass production of aluminium was present, the market, on the other hand, did not develop at the same pace. Despite the advantages of this metal, being three times lighter than steel, having a brilliant lustre, being corrosion resistant and at first sight easy to cast because of its low melting point, many problems were encountered upon trying to industrialise the production process. The infrastructure and know-how of the already established steel industry, e.g. its rolling mills and forging presses, proved unsuitable. The castings often had an inferior quality because of numerous

[44] Charles Hall was a student of F.F. Jewitt, the latter having been taught by Humphrey Davy. So we can understand why Jewitt inspired Hall to look for a cheap production method for aluminium.

shrink- and blowholes and although cold working could strengthen the material, the maximum tensile strength that could be obtained by strain hardening was far below that of the iron and copper alloys in use.

A great deal of the above-mentioned problems was solved with time. And as the price of the metal started to drop further following the turn of the century, new applications arose. The new metal was used increasingly for electrical transmission and auto engineers found it to be excellent for cast engine parts. But aluminium would never have attained its position as second important metal towards the end of the twentieth century, if the precipitation hardening potential of aluminium alloys had not been revealed.

Alloys that possess extensive precipitation hardening capabilities, have been used for centuries. There is, however, little, if any, evidence that this capability was recognised or used. Only recently have the abnormally high hardness and brittleness of some ancient silver coins, containing a few percent of copper and about one percent of lead, been attributed to extended natural aging – of course unintentionally obtained –.
Towards the end of the nineteenth century, some understanding of the crystalline nature of metals had already been acquired and different thermal treatments had been developed for steel and its alloys. The thermal practices for non-ferrous alloys, on the other hand, were generally limited to preheating for hot working and annealing of cold worked material. Phase diagrams were only roughly known and solubility limits had rarely been subjected to detailed investigation. The first author to mention decreasing solubility with decreasing temperature was H.W.B. Roozeboom[45] stating that "a solid solution may reject one of its components or a compound, as does a liquid solution, when it is cooled, this was an entirely unknown phenomenon a few years ago, but it has now been demonstrated in some cases which have been the object of studies by my pupils".

In 1909, the "Deutsche Waffen und Munitionsfabriken AG" persuaded Alfred Wilm, at that time only recently appointed head of the metallurgical department of the "Zentralstelle für Wissenschaftlich-Technische Untersuchungen" near Berlin, to initiate a research program to develop a light alloy which would be suitable for the production of cartridges for infantry weapons and with a workability, machinability and stability similar to that of a 72% Cu cartridge brass.

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[45] Roozeboom H.W.B. : Ztr. Für Physikalische Chemie 34, p.437 - 1900

Numerous treatments were tried out on aluminium alloys with copper, magnesium, manganese and several patents were taken. Some results were very spectacular, e.g. tensile strengths of over 400 MPa, which is more than double the strength of unalloyed aluminium. Unfortunately, the results were inconsistent and large variations occurred.
One story then explains how Wilm and his assistant, Fritz Jablonski detected the crucial importance of *holding time*. It was a Saturday night and Jablonski wanted to rush home. But at the urgent request of Wilm, he had hurried to do a hardness test on a piece of Cu-Mg-Si alloy that had just been taken out of a furnace and quenched from a temperature of 520°C. The result was not very promising, as the hardness was only slightly higher than prior to the treatment. Since he was not convinced by this result, Jablonski repeated the test on Monday morning and found a spectacular increase in hardness. Those results were so intriguing that Wilm and Jablonski decided to repeat the heat treatment and measure the sample's hardness after several hours of "aging" at room temperature. Their results were shown in the graph of the figure 10, which was the first published PH graph and was followed by hundreds of such graphs in the decades that followed.

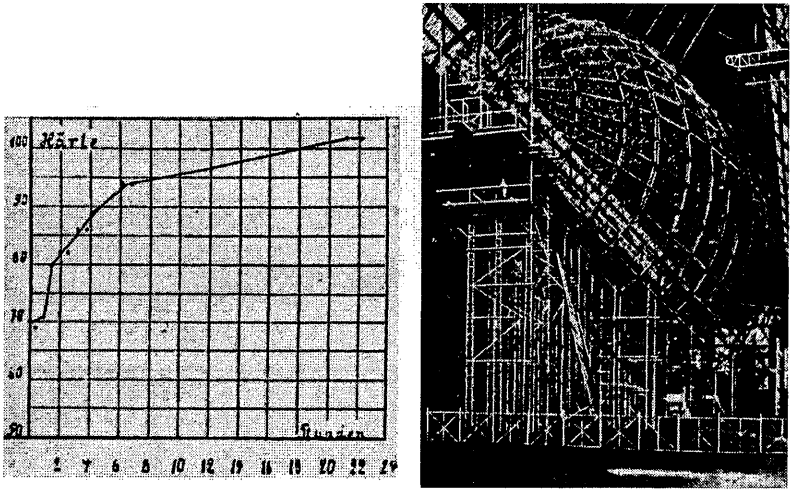

Fig.10 : The first aging curve made by Wilm in 1911 and the skeleton af a Zeppelin, representing the structural application of aluminium[46]

[46] H.Y.Hunsicker and H.C. Stumpf "History of Precipitation Hardening" in "TheSorby centennial Symposium on the History of Metallurgy" American

The Berlin Centre did not see an improvement in formability compared to the brass cartridge material and was therefore not really interested in commercialising the patent; therefore Wilm took it with him to the Dürener Metallwerke. The precipitation-hardened material therefore obtained the name Duralumin. The first successful production run amounted to 12.75 ton of which ten ton was used for the construction of airships.
The Zeppelin Airship Factory in Friedrichshafen indeed initiated structural experiments towards utilising the greater strength of this material in order to optimise the design of the skeletal framework (fig.10). During the First World War, production volume increased to 720 ton in 1916, of which dozens of airships were made.
In this same war also began the first series production of an all-metal airplane, the Junkers F13, with its complete body made of aluminium sheet, thus replacing the wooden airplanes of the past.
When later the stronger Duralumin alloy was considered, which unfortunately had a lower corrosion resistance than pure aluminium, a product called "Alclad" was developed. This product consisted of a strong alloy precipitation-hardened core, physically sandwiched between thin layers of nearly pure aluminium.
Further improvement of the precipitation hardenable aluminium alloys took place in subsequent decades, and aluminium has remained ever since *the* construction material for the body of commercial aircrafts.

ELECTRICAL CONDUCTIVITY, STRUCTURAL PERFECTION AND MATERIAL PURITY: HINGES OF THE COMMUNICATION ERA

Metals have large number of free electrons, which are not bound to individual atoms. These negatively charged particles easily move when under the influence of an applied voltage. However, along their path they collide with lattice atoms or with irregularities in the metal structure such as solute atoms, dislocations, vacancies and second phases. These "lattice defects" reduce the mean free path between two collisions, thus increase the electric resistance of the material. Hence, cold deforming, impurities or alloying elements reduce the electric conductivity of metal conductors like silver, copper, aluminium, etc..

Society of Metals – ed. C.S. Smith – Gordon and Breach Science Publisgers NY (1963)

Compare a metal like aluminium with silicon. The two elements are neighbours in the Periodic Table, which means that they are nearly equally light. Their metallic appearance is also similar. The electrical conductivity of aluminium is, however, eleven orders of magnitude (10^{11} times) better than that of silicon. The reason for this can be found in the completely different and much stronger bonding in silicon[47]*, where electrons are forced to be shared between neighbouring atoms. When a voltage is applied, the electrons remain immobile, until the voltage reaches 1.1 Volt. Once the –covalent– bond is broken, the electrons can move freely. The silicon crystal hence acts as a switch: no current flows below 1.1 Volt, whereas above 1.1 Volt, the metal conducts the current. Silicon therefore is often described as a semi-metal or a semiconductor.*

Of course, any disturbance of the perfection of the silicon crystal also has its effect on the performance and reliability of this semiconductor. Foreign atoms bring new conducting particles into the lattice. When this is done intentionally and under strictly controlled conditions, we are dealing with "doped" semiconductors– which have a higher –but controllable- conductivity than pure silicon. This doping is needed in order to make transistor elements. But other disturbances, like grain boundaries, dislocations, vacancy clusters have uncontrollable effects and always deteriorate the quality of the material.

The first transatlantic cable

We admire the versatility of authors and scientists of Renascence and Enlightenment times. They were able to exceed the boundaries of their own discipline.

One example of this versatility is found in William Gilbert, born in Colchester under Elisabeth I. He graduated as a medical doctor in 1569 at Cambridge. He became a member, and in 1600 even the president, of the Royal College of Physicians in London. However, this did not prevent him from editing, in the same year, his book "De Magnete", which is in fact the first standard work about electrical and magnetic phenomena. Although the book was not free of alchemy-like statements and parts of popular belief were treated seriously –like the influence of garlic on the performance of the compass–, Gilbert was the first to clearly distinguish between magnetism and static electricity. Magnetism, he wrote, is the soul of the earth, indicating the

[47] Silicon has a diamond-like lattice with covalent bonding between the atoms. The much stronger bonding also explains the great difference in melting point between aluminium (660°C) and silicon (1414°C).

relationship between the polarity of the compass needle and the earth's magnetism. Static electricity, on the other hand, is the effect that occurs when a material, after having been rubbed with a cloth, attracts dust particles and chaff, or the effect that leads to the undesired experience that you get an electrical shock when touching a metallic doorknob after having walked some steps on a carpet. Gilbert called this phenomenon "electric force", a word based on the old Greek word for amber, the material he used for his experiments on static electricity. Thus, four hundred years ago, the etymological foundation was laid for concepts like electric charge, electricity, electro-technics, electronics etc... words which nowadays belong to our daily vocabulary.

In 1729, the English chemist, Stephan Gray, observed that electricity being generated in a piece of amber or glass could be transported over several hundreds of meters through a brass wire. Electricity, he concluded, is not inherent to a given place in the material, but can move through this material. The subsequent development of electricity consisted of a series of inventions, driven by a combination of curiosity, entrepreneurship and accidental luck. We limit the further text of this part to some topics, which illustrate the growing attention that was given to the metal copper.

Benjamin Franklin (1706-1790) closely followed the developments that were taking place in electricity. He was especially interested in the so-called "Leiden vessel", in which an electric charge could be stored. He thought that such a vessel could allow him to demonstrate that lightning was an electric phenomenon. During a heavy thunderstorm, he flew a kite that was linked to a Leiden vessel by a humid silk tow. The first stroke of lightning already electrically charged the vessel. This experiment inspired him to mount a steel wire as a lightning conductor on top of the St Paul's cathedral in London in 1769. Three years later, in 1772, the cathedral was hit by lightning and it was indeed observed that an electric current was flowing through the conductor, thus protecting the cathedral from damage. However, it was equally observed that the conductor became red hot at some places. The logical conclusion, taken by the crew, was to replace the steel conductor by a copper one. At that time, the famous Cambridge Physicist Henry Cavendish (1731-1810), had indeed shown that copper was a superior conductor compared to steel. Copper is even the second best metallic conductor, with silver being the best.

From that moment on, copper played a leading role in the further development of electrical engineering. Volta tested this metal for its

performance as a battery material and towards the mid 19th century, copper entered the first electric machines –the dynamo, the electric generator, the electric motor and the transformer– as a conducting material.

The invention of the telegraph by William Cooke and Sir Charles Wheatstone in 1830, led to the first important application of electric copper cables. The first one was laid over land, namely from Euston to Chalk farm in London. But shortly thereafter the idea of laying a connection between Dover and Calais became reality. The latter undertaking had to be repeated three times before the right cable construction and a suitable isolation material was found. In 1861 the connection finally could be taken in operation.

As a result, the idea to connect the US with Europe with a telegraph cable gradually arose.
The transatlantic cable project has become one of the most heroic projects of modern engineering history, and one of the summits of technological progress in the nineteenth century. Again, several attempts to install the cable from especially designed and equipped ships –the Agamemnon and the Great Eastern (fig. 11)– failed.

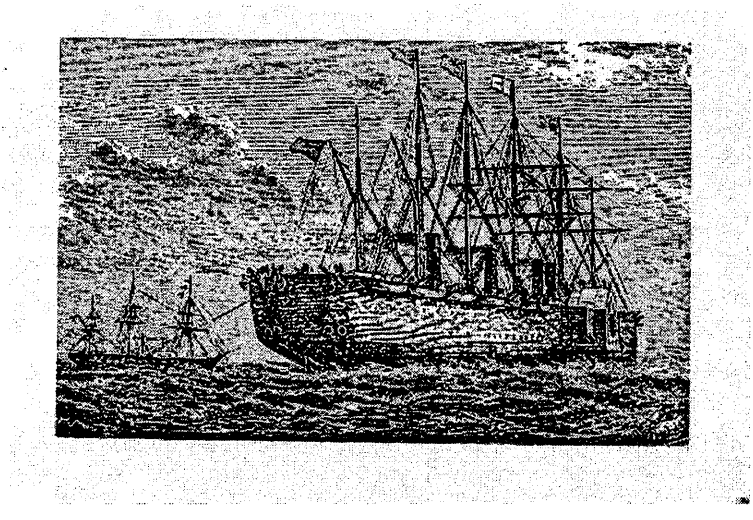

Fig. 11 : Artist's view of the Great Eastern, one of the two ships that laid the first transatlantic cable.

Again long discussion meetings followed about the optimal dimensions and design of the cable construction that would minimise the electric current losses over the 3700 km long distance between Nova Scotia and the isle of Valentia at the Irish coast. Finally, the engineers decided to take the advice of Sir William Thomson –the well-known Lord Kelvin– seriously, namely to make the cables from high-purity copper. Indeed, the first conductors had been purchased without any specification of conductivity, and one length of cable, made from arsenical copper from Rio Tinto was found to have only 14% of the expected conductivity[48]. This forced the copper producers to improve their production process in order to increase the purity of the material from 98% of that of "blister copper" to a purity of more than 99%[49]. Thus, the increased purity of copper substantially contributed to the successful completion of the Atlantic cable project in 1866. Thomson received a knighthood for his contribution.

New transmission lines for telegraph were laid in subsequent years over land as well as over sea. And with the invention of the telephone by Alexander Graham Bell in 1879 and the electrical distribution station in 1881, the demand for copper wire increased at a spectacular pace towards 2 million tons per year towards the end of the 19th century.

A consequence of this increased demand, copper mining started in Belgian Congo, Zambia and Chile: it was the beginning of the colonial part of modern metal history.

From Edison to Schockley

There are good reasons to call Thomas Edison the Leonardo da Vinci of Modern times. His 1093 patents indeed illustrate his enormous creativity[50]. There are, however, differences between both of them. Edison also made most of his inventions work, whereas Leonardo seems to have been satisfied

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[48] Cyril Stanley Smith "Metallurgy as a human experience" Metall. Trans. Vol 6A – (1975)

[49] Kelvin knew about the measurements of electrical resistivity of several metals by Henry Cavendish (1803), and his feeling that impurities or alloying elements could dramatically reduce that conductivity, was later confirmed by Matthiessen (1860).

[50] Kathleen McAuliffe "The undiscovered world of Thomas Edison" – Atlantic Monthly – 12 (1995)

with a number of nice sketches of numerous technical installations, before going back to work behind his painting easel or in his sculpture workshop. The two had creativity in common as well as the fact that neither one was a real scientist. Their main objective was creating, Leonardo on paper, Edison in reality. Neither was really interested in the fundamental mechanical or physical mechanisms behind their inventions.

Nevertheless, as far as Edison is concerned, there seems to be one exception. Amongst all his patents, one is related to the field of "pure science". Discovered in 1882 by William J. Hammer, a young engineer working in the Menlo Park laboratories[51], it became gradually known as the "Edison effect"[52-53]. Edison never applied the concept to one of his own inventions, but it was nevertheless an important finding. It anticipated the discovery of the electron as the carrier of electrical current by the British physicist, J.J. Thomson, in 1897. It thus became the basis of the vacuum electron tube and laid the foundation of the electronics industry.

The vacuum tubes were simple rectifier and amplifier devices that were state of the art of the electronics industry during the first decades of the 20th century. They were much more reliable than the elder point contact crystal rectifiers. With the advent of new communication equipment and radar, however, it appeared that the vacuum tubes were not suited for the high frequencies at which these devices had to work.
In the late thirties, a researcher in the Bell Laboratories, named Russel Ohl, still believed that there was a future for crystal devices. He was persuaded that these devices should become much more reliable if crystals of higher purity could be made. Not without trouble, he succeeded in persuading his boss Mervin Kelly to provide a budget for his research on silicon crystals. He soon could show that 99.8% pure crystals behaved much better as rectifier

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[51] One of the greatest accomplishments of Thomas Edison was the construction of the first industrial research laboratory in history, affectionately called by Edison "the invention factory", but more formally known as "the Menlo Park Laboratory" which would gradually evolve into the Bell Labs.

[52] When testing Edison's light bulbs, Hammer noted a blue glow around the positive pole and a blackening of the bulb at the negative pole. This was later explained by the thermo-ionic emission of electrons from the hot to the positively charged cold electrode.

[53] The phenomenon was first known as "Hammers phantom shadow", but when Edison patented the bulb, it became known as the "Edison effect".

than its less pure predecessors. His most important finding took place on the 23rd February 1939, when he was comparing the amount of current travelling on both sides of a crack that went down the middle a silicon crystal. He then suddenly detected that the conductivity the crystal could be enhanced by holding it above some boiling water or underneath a strong shining light bulb.
He repeated the test in presence of his director Mervin Kelly and of Walter Brittain, a colleague recognised in the Bell labs as a most experienced experimentalist.
The light bulb test worked. There was instant surprise followed by weeks of reflection until it became clear what had happened. The crystal had different levels of impurities on either side of the crack. One side had, due to subtle traces of extra elements an excess of electrons – was n-type- , the other side a deficit –hence p-type-. Being in contact with each other a so-called "barrier" was formed at the tip of the crack. When electrons were mobilised by incident light, a current started to flow but the barrier only allowed it to move in one direction, namely from the n- to the p-side of the crystal.
The first p-n junction, the precursor of the solar cell, was born.

But the Bell labs and Melvin Kelly in particular were not so much interested in those days in the application of Ohl's crystals as solar cells, but in the idea that extremely pure crystals, doped in a controlled way by selected elements, might open the possibility of replacing vacuum tubes.
Kelly then decided to form a team of scientists with the goal to develop a semiconductor circuit that could replace the vacuum tube. Bill Schockley – a brilliant scientist- was appointed leader of the team. He, at his turn, selected the mentioned Walter Brattain and John Bardeen to be part of his crew. After several disappointing tests with silicon, the team decided to switch to germanium, which has the same structure as silicon. It was Gordon Teal, a crystal expert working in the shadow of the three "masters" of the Bell labs, had indeed succeeded to produce germanium single crystals with much higher purity than the silicon material Schockley's group was working on[54],[55]. Science historians mention the "exuberant parties and good lunches" during the seven year the team worked together; however, these years were

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[54] G. Teal and J.B. Little "Growth of germanium single crystals" Phys. Rev. 78 (1950)647
[55] Germanium crystals can now be produced with only one impurity element for every 10^{12} atoms.

not free of tensions, due to competition or disagreement, apparently often induced by the obstinate character of Schockley.
Anyhow, the 30th of June 1948, the Bell Labs could present the first germanium transistor to the press. And in 1956, Schockley, Bardeen and Brittain received the Nobel Prize in physics.

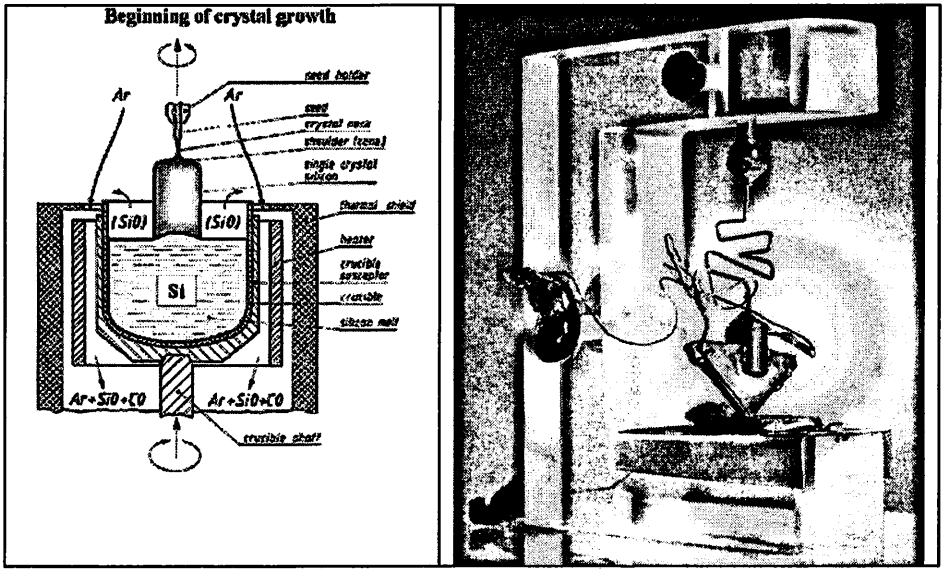

Fig. 12 : The Czochralski method of crystal growth.
Essentially a crystal is "pulled" out of a vessel containing liquid Si by dipping a "seed crystal" into the liquid, which is subsequently withdrawn at a surface temperature of the melt just above the melting point. Traces of impurities remain in the melt.

Copy of the primitive first transistor made by the Schockley, Bardeen, Brittain team.

After his success with germanium, Gordon Teal had continued research on silicon crystals and tried to improve their purity by applying the crystal

growing Czochralski method[56]. He was discovered by Texas Instruments, who persuaded him to join their company. A few years later, in 1954 TI could unveil the first silicon transistor. Silicon is not only much cheaper but it has a number of operational advantages[57] over Germanium.
Four weeks after the presentation of Gordon Teal's transistor, the first silicon triodes were in production.

In the meantime, Schockley had left the Bell Labs to create Schockley Semiconductor in Palo Alto, California. There, he also attracted top-engineers and physicists, however not for a long time, since similar conflicts as before arose in Schockley's team. For similar reasons, eight people left the company to create Fairchild Semiconductors. Two of these eight, namely Bob Nyce and Gordon Moore founded Intel Corporation. Together with the Texas Instruments labs, Intel laid the foundation of the integrated circuit allowing millions of transistors and other electronic components to be grafted on a centimetre-size silicon wafer. It was the opening of the ICT era and the start of the Information Society.

SUMMARY AND CONCLUDING REMARKS

Metallurgy and History

Starting from the chalcolithic period, the development of new metallic materials and metallurgical processes had a decisive influence on the history of technology and even on the course of European –Western- history. The transition from stone to Copper brought the early settlers in contact with totally new materials with hitherto unknown properties: it was the start of numerous new crafts and a continuously expanding variety of metallic tools, weapons and systems.
Gold extended the duration of Pharaonic Egypt, it was the ideal instrument for Mediterranean people to change from barter to monetary trade, and it underlined the power of Thracian warlords and Celtic Oppida leaders. The Laurion Silver lode provided the visionary Themistocles the means to put the Athenians at work to build a powerful navy that for once and forever freed

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[56] G. Teal and J.B. Little "Growth of germanium single crystals" Phys. Rev. 78 (1950)647
[57] For some applications, germanium has a better performance than silicon, e.g. for satellite solar cells.

Europe from Persian occupation, thus paving the path for Classical Greece to develop into the cradle of Western Civilisation. The Bronzes were the first really technical metallic materials, much wanted by the farmer and the soldier, and, because of the relative scarcity of tin and copper deposits, gave a great stimulus to the development of trade over land and over sea in Western Europe and the Mediterranean.
Once metallurgists succeeded in controlling the Hittite sponge iron or bloomery process, and because of the abundance of iron ore, steel gradually took over the role of the bronzes and intruded agricultural, military and civil engineering workshops from southern till northern Europe. The quality of iron and steel tools and weapons played a decisive role in the development of agriculture and sometimes also in the outcome of wars. When after nearly 3000 years of iron metallurgy, western European metalworkers were able to heat their high furnaces to the point of making liquid pig iron and later on capable to transform that pig iron into different steel qualities, the first signal of the looming industrial revolution was given.
Steelmaking know-how was transferred first from Wallony to Sweden and later from Great Britain to the continent. It was a dynamic movement of industrial and economic centres of gravity over Europe, taking place in the stimulating atmosphere of the Enlightenment. In that same period of Enlightenment, new elements of the Periodic Table were discovered one after the other, one of the most important being Aluminium. Barely fifty years later, strong aluminium alloys gave a great impetus to the development of today's civil air transport.
Scientists and engineers from the early twentieth century then laid the foundation for a metals and materials science, which is expanding into several high-tech developments of the new millennium. The article closes with the story of the first transatlantic cable and that of the first transistor. In both cases, the improved purity of the material –copper viz. silicon– allowed a breakthrough towards the development of modern information and communication technology.

Metal Properties and History

Behind the successive stories of the present paper, covering eight millennia of human history, the application of always new properties of metals is hidden. For the physical explanation of these properties and their relation to structure and process conditions, one had to wait for the development of metal science which took place during the twentieth century.

The first property was the one that distinguishes metals most from stone materials like flint and other quartz varieties: the possibility of bending and forging them without rupture, revealing the potential of *plastic deformation.* It is this property that opened the metal age, the chalcolithic hinge. The discovery that these materials were harder after than before hammering soon followed. This phenomenon is called *strain hardening.* The observation that a strain hardened implement, having been dropped in a fire, regains its original softness faced metal workers with the mechanism of *recrystallisation.*
The value of the noble metals gold and silver was not only determined by scarcity and precious colour but even more by their durability thanks to their *oxidation and corrosion resistance. Alloy hardening* –mainly by solid solution strengthening– was the physical base for the success story of the bronzes. *Allotropic phase changes of iron* and the specific pattern of the *iron-carbon phase diagram* allowed for a multiplicity of thermal treatments, fiddling microstructure and properties of steel and cast iron, thus widening the applications of the iron-based materials for engineers, farmers and warlords. The *thermodynamics and kinetics* of reactions in smelting and melting furnaces can a.o. explain the progress that was made by the introduction of the Walloon furnace, and the metallurgical contributions to the industrial revolution namely the coke fired blast furnace and subsequent refining technologies.
The development of *precipitation hardening* treatment is the base of the successful introduction of aluminium in airplane construction whereas the influence of impurities and lattice defects on the *electrical conductivity* of copper and on the performance of the semimetals germanium and silicon as *semiconductor* materials scientifically explain the recent ICT hinge of human history.

It was mentioned earlier that the blacksmiths of classical times were persuaded that keeping an iron dagger or knife in contact with a hot charcoal fire for a sufficiently long time, was a process of purification. Many other explanations of the effect of alloy additions and thermal or mechanical treatments on the properties of metallic materials were interlarded with mythical stories and superstition –like the story of William Gilbert, discussing the influence of garlic on the working of the compass needle–.
Though superstitious thoughts disappeared with time, we had to wait till the late nineteenth century before scientists started to suspect that differences in properties between metals and alloys were not only due to differences in chemical composition but also to differences in structure.

The allotropy of iron was proposed around the turn of that century as being "different molecular states of iron" [58,59] and attempts were made to relate the hardening of steel to the existence of these two phases[60]. It is surprising to hear that several steel varieties –tool steels and even stainless steel– and aluminium alloys were developed before the crystal lattice structures of iron and aluminium were known. Harry Brearly, one of the inventors of stainless steel once said: "at the best, metallurgical science hitherto was able to explain what the metalworkers already knew for a long time." And Henry Clifton Sorby, an English geologist, who is generally recognised as the first who used a microscope to study the structure of metals, referring to the situation around 1870 wrote: "In those early days, if a railway accident had occurred and I had suggested the company to take up the rail and have it examined with a microscope, I would have been looked upon as a fit man to send to an asylum."[61]

In every case, even up to the middle of the twentieth century, practice in metallurgy was far ahead of metal science. Only in the early decades of that century, the crystalline nature of metals could be experimentally proved by X-ray diffraction. From then on, the nature of different phases in metallic alloys started to be revealed.
The development of always more advanced investigation techniques, together with numerous successful efforts to model processing-structure-property relations speeded up the development of all fields of metal science. Nowadays, metal and metallurgical sciences have become indispensable instruments of innovation in the metallurgical technology of today.

Moreover, the evolving metal science also laid the foundation of a much broader materials science and engineering. This reflects –as will be shown– a "materials hinge" of historical importance, namely the end of the domination of metals in the materials world of the early third millennium.

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[58] " Théorie cellulaire des propriétés de l'acier" F.Osmond and F.S. Werth – Annales des Mines 8,5, (1885) and Mémorial de l'Artillerie de la Marine » 15, 225, (1885)
[59] " On the Manufacture of steel armour-penetrating shells" (in Russian). D.K. Tschernoff- Notes of the Russian Engineering Society 6, 83, (1885) Quoted by V.D. Sadovsky in
[60] The Sorby Centennial Symposium on the History of Metallurgy" – ed. C.S. Smith – Gordon and Breach science publishers – (1965)
[61] "Sorby: the Father of Microscopical Petrography" – D.W. Humphries in [3]

The end of the domination of metals

Starting from the 17th-18th century, the centuries of Enlightenment, history became more personalised, also outside the field of religion and philosophy and of political and military power. The conviction that men could understand creation and dominate the world became widespread. Therefore, science and scientists entered the spotlights. Gradually, chemistry started to leave the crypts of alchemy and delivered hard scientific matter. Between 1750 and the end of the 19th century, the number of known elements increased to a multiple of those that men had succeeded to isolate in the millennia before[62].
Many of them have become of great importance in our technological world, not only as an alloying element of the base metals but also as an individual element in numerous applications: zirconium in nuclear power plants, titanium in medicine, petro-chemistry and aerospace, germanium in satellite solar cells etc.

However, besides metallic materials, new very-promising families of non-metallic materials appeared, first at a low but in the second half of the 20th century at increasing pace. These are the man-made polymers, the technical ceramics and a great variety of composite materials. They not only opened a whole world of new applications, but also increasingly act as competing materials or even as substitute for metals and metallic alloys. Progress in the metal field continues, but we have to recognise that we entered an era, in which the four material families –ceramics, metals, polymers and composite materials– have attained equal importance for shaping the future technological world.

Beware of Euro-centrism

Nearly three millennia ago, in the Lake Superior region in North America, a huge deposit of native copper was exploited by the local Indians. The metal was squeezed out of the rocks by hammering and subsequently used in its

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[62] Nickel (1751), Manganese (1774), Cobalt (1780), Tellurium (1782), Titanium (1795), Niobium (1801), Palladium (1803), Rhodium (1804), Magnesium (1808), Cadmium and Selenium (1817), Zirconium (1821), Aluminium (1825), Silicon (1854), Thallium (1861), Indium (1863), Gallium (1875), Germanium), (1886), Beryllium (1898).

native state, not only for a variety of ornaments, but also for tools, utensils and weapons. Pre-Columbian Indians thus equally had their Chalcolithic hinge.

In South-America, in the so-called "Antiplano" of Bolivia and Southern Peru, the start of a settled village agriculture stimulated the development of smelting processes: remnants of mining sites learn that Copper extraction metallurgy was known from at least 2000 B.C. whereas the oldest known copper objects stem from 1200 B.C. [63]. The technique of copper smelting used by the Incas and described by the Spanish conquistadores –several men rhythmically blowing through tubes into a heap of intermingled malachite ore and burning charcoal– probably did not differ much from the smelting techniques used in Eurasia several millennia earlier. In Peru, arsenic-bronze was discovered between 200 and 600 A.D., and remained the alloy of choice until tin-bronze became the official standard after the formation of the Inca state about 1470[64]. Furthermore, we should not forget the advanced metallurgy and especially the special surface technologies developed by the Incas to extract the copper atoms from the surface of gold-copper ornaments, leaving the impression of pure gold [65].

As important, if not more, are the metal hinges in the history of East Asian countries. The Bronze Age and bronze trade developed during the same era as in the times of the Celts and the Thraciëns in Europe, hence before classical Greece and Rome; their influence on the history of China, India, Vietnam ... attracts increasing interest of archaeologists. It is an established fact that the copper-zinc alloy brass was developed in India and that the condensation process of zinc extraction also was an Indian invention.

Cast iron metallurgy was developed in China from around 500 B.C. and had an enormous influence on Chinese agriculture, shipbuilding and military

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[63] "A concise history of Bolivia" Herbert S. Klein, Cambridge University Press 2003

[64] CATHRO, R.J., 2000. The history of mining and metallurgy in Latin America, 1500 BC–1600 AD. In Volcanogenic Massive Sulphide Deposits of Latin America. Edited by R.L. Sherlock and M.A.V.. Logan. Geological Association of Canada, Mineral Deposits Division Special Publication No. 2, p. 2-3

[65] Noble metals were, however, so abundant in the Inca Empire that the population attached more importance to a nicely woven carpet than to a golden statue, they detected the value of their precious metals only when the Conquistadores started to disintegrate their Empire mainly for its gold and silver riches.

infrastructure till 1500 A.C., when a mysterious decline occurred. The western world on the other hand had to wait another three centuries before cast iron metallurgy started to reach technological maturity.
Therefore, the present article was consciously focussed on metallic hinges in *Western* History. These are only part of the metallic hinges in World History. Even in the field of the history of metals, we should beware of Euro-centrism.

Innovation: lessons from history
An obvious question of today's researchers is how, all along human history, people came to new metallic materials and how to the development of new metallurgical processes. Was it always necessity that spurred the inventive efforts? Was it always market pull?
No, it was not. Copper metallurgy was not developed because there was a shortage of stones. It was developed because craftsmen and artists, surprised by the red drops on a furnace wall and the peculiar malleability of these drops, made an ornament of them, before others became aware that the material opened a number of new, interesting and useful applications. In a similar way, we could state that today's need for automobiles and trucks arose *after,* not before, they were invented.
Thus, necessity and utility solely cannot account for the variety and novelty of the artefacts created by humankind; we must seek other explanations[66].
Cyril Stanley Smith[67] stated, "Discovery is less likely to occur when people are desperately earnest, than when they are in a sensitive, somewhat playful mood. The artist's sensitivity to colour and texture naturally brings him into contact with more properties of materials than are encountered by the maker of useful objects".
Very often indeed, the curiosity of the craftsman has been a much greater stimulus to inventions than the "animal need". This explains why most of metallurgy, both alloying and heat treatment, as well as mechanical shaping often first called attention from art, fashion and ceremonial events.
It teaches us that freedom of research, pleasure in beauty and unexpected properties, and entrepreneurial open-minded curiosity are ingredients of utmost importance for an academic research team.

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[66] "The evolution of Technology" –George Basalla – Cambridge History of Science Series- Cambridge University Press – 1988
[67] C.S. Smith "Metallurgy as a human experience" – Metall. Trans. Vol. 6A – apr. 1975

Secondly, "invention" is often better defined as "innovation", because it is the result of combining existing and known elements in order to "invent" a new element. All along history, up to the present day, technological change was not accomplished by a series of great unrelated leaps forward by a few heroic inventors. Instead, the form of a "new" or "modified" artefact was mostly based on that of pre-existing predecessors, and it is very often true in the development chain of new materials and processes, links of "creative copying" have been of vital importance.
It was mentioned earlier how the names of scientists and inventors entered the spotlights since the Enlightenment. This can, dangerously, lead to a heroic theory of invention, in which previous small improvements in technology, leading to the invention, are ignored and all emphasis is laid upon the individuals that made the final major breakthrough. The lost wax metallurgy for the bronzes is said to have been developed in Egypt, but who knows what the Egyptians had learned from previous trials in Mesopotamia and farther East? Darby I is recognised as the father of the coke blast furnace, but his development was based on the experience of malt-making shops and on the less successful experiments of others with coal. And although Russel Ohl and Gordon Teal made fundamental discoveries, leading to the development of the –of course more revolutionary– transistor, their contribution to the production of ultra-pure semiconductor crystals and to the invention of the semiconductor junction has been largely forgotten[68] .

Finally, even in today's high-tech world, basic principles are in many cases derived from practical experiments, often by chance, thus reversing the orthodox concept of pure research leading to applied research. Hence, formally trained scientists, though their contribution to metals science and to the development of new metallic materials has to be recognised – and becomes of increasing importance- should never depreciate the engineering contribution to a world, hitherto largely shaped by the history of metals.

[68] http://www.ieee-virtual-museum.org

LAUDATIO GASTON VAN DE WALLE

Marc De Clercq

Who considers the life and work of our colleague, Gaston Van De Walle, cannot but conclude that he rightfully deserves the Sarton Medal. The dean explained in his introduction that this medal is a reward for scientists who have fought for the study of the development and history of their field. Gaston Van De Walle did this – and keeps on doing that – *par excellence* in the field of the economic science.

In this laudation, I will glance through the career of our former colleague Van De Walle. This is particularly interesting for those who have not known him as a professor, because his career is typical for a generation that is exemplary for the burgeoning democratization of higher education in Flanders.

Gaston Van De Walle was born in Ghent on the 25th of june 1923. He graduated as a primary school teacher, and later on he completed the lower level secondary school training. He studied languages in evening school and enrolled at university after World War II. He combined his studies with teaching. He graduated with great honor in 1948, and became teacher of commercial science. He got tired of this technical matters and started to take courses at the university. He graduated in 1953 in the complementary studies of economics. He started teaching in a secondary school, but was sent on secondment to Ghent University at the Seminar of Economics and International Economics (director Prof. Dr. M.A.G. van Meerhaeghe), and received his doctors degree in 1963 with the greatest honor. The subject of his thesis was the business cycle in Congo and Ruanda Urundi. His secondary thesis dealt with the attitude of the German social-democrates towards the Marxian doctrines. He started working at the University of Antwerp in 1964, and became censor of the Belgian National Bank in 1966. He was appointed parttime lecturer at Ghent university, and was appointed in 1968 as full professor at the University of Antwerp. Four of his former assistants in Antwerp are now professor at the University of Antwerp.

He resigned from his university tasks in Antwerp and Ghent in 1988, and quitted working in the National Bank in 1992, and started working parttime as advisor at the Institut Belge de Formation.

I will not irritate you by reciting the scientific publications of Gaston Van De Walle, because he has written plenty of them. On the contrary, I will point out some general features.

The research of Gaston Van De Walle was concentrated on three subjects:

The first and most important is his interest in the development of the economic science, the reason which we are here for. This interest hhad his "opus magnum" as a result. His "history of economic thought" counts nearly 500 pages. Furthermore, he wrote numerous smaller and more substantial studies on important and less important economists (for instance Marx, Vandevelde, Hilferdink, Enrico Barone, Friedman, Sismonde de Sismondi, Keynes...), and he gave lectures on regular basis on the meetings of the Society for the History of Economic Thought, that took place at British universities. It is important that he links the development of the economic thinking to the broader developments of society, and to the general developments in social and philosophical thinking. In his opinion, economy still is a very interesting social science, in which the views of society interfere with economic theories, an attitude he will certainly demonstrate again in his lecture. He possesses a great amount of erudition, a skill which is mostly lost nowadays. He has read the writings of almost every pioneer in economic sciences, often in the original languages and original edition. He did not confine himself to the writing of the pioneers, but read also their predecessors, who brought about the changes, and their epigones, who sometimes played an important role in the translation of the theories to society and in the alerting of policy makers. This was possible because Gaston Van De Walle possesses three rare qualities.

The most important of all is his patience. He is capable of reading in the confinement of his study or library, to contemplate what he has read before adding material of his own. Secondly, he has an exquisite sense of synthesis. Not everyone is gifted with the talent of expressing an economic doctrine with few words. He does what every important professor does with his students and society in general, he explains difficult topics in an easy way. Prof. M.A.G. van Meerhaeghe certainly contributed to this ability to summarize, since Van De Walle was his assistant for may years. You know, Gaston, we were both assistant to the same professor, I think you were the first to write you doctoral thesis under his supervision and I was the last. I could not find many names in between. It was very typical for our former dean that he encouraged his assistants to write

in a condensed manner. If, after doing your best to write as concise as possible, you presented him a two-page text, he crossed still half of it off. The syllabus and lectures of Gaston Van De Walle were hinge points in my formation as an economist. Arduous, but also very useful. Not only because they brought about historical insight; one who doesn't know one's history is like a traveler without a m ap, who cannot find the right way to the future. But Gaston Van De Walle was also the one who informed us on the most recent ideas in economics sciences. He filled in this way some hiatus in our curriculum. A third asset of our colleague is his encyclopedic knowledge. Through his study, he obtained a bird's eye view on economics, on her strengths and weaknesses. In that way, he could place developments in a broader historical perspective and estimate their importance.

The second subject on which he stresses in the economic and politic developments of the United Kingdom. He published on a regular base in "Economische en Sociale Berichten". Here we can see another person, someone who feels the pulses of society and who can explain the important and less important political choices that present themselves.

The third stress in his scientific work is his interest in corporatism. A scientific interest procreated by social motivations, he was an active member of the Socialist Party. He published some important articles on that subject.

You could perhaps conclude from this laudation that Gaston Van De Walle was a unworldly scientist. Without doubt he is a crammer, even a bookworm, but he was able to bias his activities by taken up important social duties. He was censor of the Belgian National Bank from 1966 till 1992, and for years he was a member of the Executive Board of the former RUCA, and finally, after retirement, he was ctive as scientific advisor of the Institut Belge de Formation.

Concluding, Gaston Van De Walle is an ideal candidate for the Sarton Medal, I am happy that the faculty followed y proposal to nominate him as one, and I am looking forward to his lecture.

POLITICAL DREAMS AND ECONOMIC THEORY

Gaston Vandewalle

1. Can economics be a positive science ?

Politics and the economy have always been closely connected. In 1615 a book was published by the French mercantilist Antoine de Montchrétien(1575-1611) with the title; "Traicté de l'économie politique, dédié au Roy et à la Reine ,mère du roi ".
The mercantilists considered economics as an auxiliary of politics. Economic policy had to increase the power of the national state.
In the second semester of the 19th century some economists tried to create a more independent and objective economic science . In 1871 Léon Walras(1834-1910) published his book "Eléments d'économie pure ". By means of mathematical equations he tried to explain the way certain prices prevail in the market. Francis Edgeworth(1845-1920) used in his book "Mathematical Psychics"(1881)indifference curves to explain the pricing process in an exchange of goods between two persons. However, these theoretical treatises could but explain a limited number of evolutions in the economic field. Most macroeconomic entities such as incomes, investments, savings, interest rates etc. are determined by so many factors, of which some can not be measured, that it is impossible to explain them by means of mathematical relations. In the natural sciences relations between the diverse aggregates are discovered by means of experiments. In economics few can be implemented . In most cases some material interests are involved and the firms or persons concerned are not inclined to provide information, which could be useful for competitors. Finally economists must keep in mind that to-day the structural features of the diverse economies are rapidly changing. Relations, which have existed during a certain period, may disappear thirty years later. For example during the crisis of 1930-'35 it was possible to increase substantially the demand for goods and services by increasing public outlay. A dollar paid by the state to a firm created an income, which was almost totally used for buying domestic goods and in this way created new incomes. In the sixties most industrially developed countries applied

free trade policies. The primary income produced by public works was partially used for imported products .As a consequence the "multiplying effect "on domestic income was much smaller.
The lack of reliable methods for discovering economic relations by experiment has induced economists to use deductive reasoning. They formulate some general ideas about the ways of reasoning of entrepreneurs, employees, consumers, rentiers, investors and speculators and deduce from these premises rules about how the economic mechanism works.
Political dreams influence the choice of the premises. Most economists are not completely satisfied with the existing economic structure. Some are convinced the authorities are too lavish in granting subsidies to persons on the dole , to the sick, invalids and to poor families They believe such individuals do not want to work. The costs of helping them to survive are excessive As a consequence they tell us, taxes are too high and investment in the competitive capacity of national firms is curtailed .
Others on the contrary wish to increase social outlay. Such money is not lost for the economy.
As poor persons do not save much, the subsidies increase consumption. Demand is increased and the various firms find a good domestic market for their products .
The French, who have always much admired the positive sciences , speak about the "masters of science " . When they refer to a reputed economist they say that he is " un économiste élégant". They do not mean that he is a well dressed person , who is looking for the favours of some rich entrepreneur, who will offer him a seat on the board of a big company .They use the word "élégant" in another sense. They mean a person ,who is skilled in developing theories ,which seem to explain economic situations and suggest adequate political measures.
In the following chapters the relations between political dreams and economic theories from the end of the eighteenth century till to day are analysed.

2. The controversy between mercantilists, liberals and socialists from the end of the eighteenth century till about 1850.

As in most sciences the first extensive treatises about economics date from the end of the eighteenth century. In that period the majority of economists defended the mercantilist policies of their government. These policies were intended to favour the creation of enterprises under strict government

control. The states wished to limit the importation of foreign luxury goods and increase the exportation of national products . In this way they could obtain an influx of foreign currencies .This increased the offer of money for investment and the creation of new firms. The mercantilists thought that by practising such a policy they could increase the offer of work to a rapidly increasing population and limit the number of vagabonds and thieves. Moreover governments obtained a substantial income .by delivering patents against payment .In many cases such a document guaranteed that the beneficiary obtained a monopoly in a sector of industrial production. Mozart's opera "Der Schauspieldirektor"(1786) begins with a monologue of a protagonist, who wishes to start a theatre. The man is happy because he has finally obtained permission to realise his plans.

In the second half of the eighteenth century some economists had misgivings about the drawbacks of limiting free competition. The Frenchmen Jacques Turgot (1722-1781) and François de Forbonnais (1722-1800) tried to introduce a system of free trade. Turgot was from May 1774 till May 1776 general controller of the finances of the French state. He suppressed the regulation of the trade in grain. This was completely in the hands of a limited number of merchants. In periods of scarcity of food they profited from their exclusive right to buy grain to build great stocks, which could afterwards be sold at a large profit. Turgot intervened and stocks of grain were confiscated with the help of the army. This "guerre des farines " made a great impression on the French people. It discredited the old economic system. In January 1776 Turgot abolished the "corvées " imposed on the peasants and the "jurandes " of the artisans. This brought about heavy protest from the nobility and from the deacons of the crafts. On 12 May 1776 Turgot was dismissed by Louis XVI .

Forbonnais was also an opponent of all monopolies and privileges. As a "social" liberal he wished to reduce the heavy taxes imposed on the peasants. In 1759 he obtained from Etienne de Silhouette, general controller of finances, that more taxes were loaded on the shoulders of the rich. They had to pay taxes on footmen, cooks, carriages and several luxury goods. Voltaire complained that in the end one would have to pay a tax for breathing. The nobility protested and Silhouette was dismissed. In 1764 Forbonnais was banished, but returned after the French revolution. In 1789 he was appointed counsellor of the commission of finances in the Constituante . He published a book, entitled "Principes et observations économiques " However, he was weak in reasoning . After the publication of the translation in French of

Adam Smith's famous book "Inquiry into the Nature and the Causes of the Wealth of Nations (1779) the book of Forbonnais was forgotten.
In his book Smith proceeds from three suppositions, which constitute the basic premises of economic liberalism ,namely :

1. Free competition favours economic progress and increases the well being of the majority of the population .Entrepreneurs are obliged by the pressure of competition to apply the most efficient ways of production and commercialisation. Moreover, in order to retain their customers they improve the quality of their products.

2.. In a free market there are great differences in income. These inequalities promote saving. The rich save more than lower class persons.
Moreover, the rich are often entrepreneurs . They use their savings for the creation of new firms. As a consequence the demand for labour increases . Wages start to rise. In the end also members of the lower classes of society participate in the general prosperity.

3. The luxury of the rich urges most members of a free society to work hard in order to attain a higher living standard. This contributes to a permanent increase of the income of the nation.

Smith's ideas were well received by bourgeois society. In France the guilds and trades were suppressed after the French revolution. In Great Britain they lived on in name but their power was limited by the creation of new industries, that were not subject to guild regulation. Their legal power was abolished in 1835.
After the French revolution the quasi-permanent wars between Great Britain and France reduced the export of British products to the continent. When in 1806 Napoleon introduced the continental blockade the English merchants lost almost all chance of exporting products to Western Europe. This engendered an economic crisis and an increase in the unemployed Instead of rising, wages decreased. Most workmen lived in extreme poverty . Women and children had to look for work as the wage of the main breadwinner was insufficient to sustain a family. Many men could not find work because the factory owners replaced male workers by women and children in order to reduce their labour charges.
Council authorities, which had to provide food and shelter to orphans, lent them as workers to factory owners, who paid very low wages. This too

exercised a downward pressure on the price of labour. Smith's dream of a liberal society had become a night-mare for the lower classes .

The British clergyman Thomas Robert Malthus(1766-1834) claimed in his book " Essay on the Principles of Population (first edition 1797,second 1806,fourth revised edition 1807) that the lower classes had to account for their poverty. The poor generated too many children and in this way increased excessively the number of persons looking for work. On the contrary the members of the richer classes limited their number of children in such a way that they could provide for their upkeep.

David Ricardo (1772-1825),a stockbroker, who had enriched himself and lived as a rentier, published in 1817 his book " The Principles of Political Economy and Taxation" (second edition 1819, third 1821). He agreed with Malthus that the lower classes had as a rule more children than they could bring up. Therefore there was a regular surplus of labour and the wages were reduced below what was strictly necessary for the maintenance of a family.

As a consequence many children died ,which caused a reduction in the offer of labour.

Wages rose, but again the number of children, who survived , increased till the offer of labour surpassed the demand. Ricardo did not believe that technological progress would improve the fate of the working classes. The average wealth of the citizens would increase, but many labourers would lose their work.

The theories of Malthus and Ricardo were popular with the prosperous, as they exculpated the rich from any responsibility in the extreme poverty of the majority of working class families. However, they ignored that workmen had to accept the wages they were offered.. They could not defend their interests by organising trade unions. The Combination laws voted by the British parliament in 1799 forbade the creation of syndicates and the organisation of strikes.

Not everybody agreed with Malthus and Ricardo. The British philosopher Thomas Carlyle (1795-1881) considered them as "The honourable professors of a dismal science ".

The Scottish entrepreneur Robert Owen (1771-1854) thought that by creating producers' and consumers' co-operatives he could improve the living standard of the labouring class. His efforts to create first in Scotland and afterwards in the United States consumers' co-operatives failed .Finally in 1844 some weavers of Rochdale, a town close to Manchester, succeeded in establishing a co-operative, which survived. This example of " The Equitable Pioneers of Rochdale " was imitated in many industrial towns and finally led

to the establishment of a powerful co-operative movement in Great-Britain during the second part of the nineteenth century .

In France the first socialist theories appeared in the second half of the 18th century .Gabriel Bonnot de Mably (1709-1785) and Morelly (a penname for an unknown author) contested the contribution of private property to the general prosperity. During the years which followed the French revolution and during the reign of Napoleon a new class of wealthy peasants and petty entrepreneurs had acquired political power. They found devices which prevented the elimination of British competition resulted in a greater demand for workmen and an increase in wages. The law Le Chapelier (1791) prohibited the creation of trade unions. Workmen could not leave easily their employer to look for better paid work They had to give their boss a "workman's book", in which the employer could write his appreciation of the workman. By inscribing an unfavourable notice or retaining the "workman's book" the employer could make it difficult for the labourer to find another job.

After the overthrow of Napoleon (1814) Europe was flooded with British industrial products. Many continental firms could not compete and had to close . As a consequence the number of unemployed persons increased and wages went down. As a reaction on this situation new socialist theories appeared. Charles Fourier (1772-1837) published in 1822 his book " Traité de l'association domestique agricole ou attraction industrielle ". He explained that he wished to redeem workmen from the « industrial galleys « by creating producers' co-operatives, named « Phalanstères «. The members of these societies would work alternatively in agriculture and in workshops. He supposed, an idea we shall find in most socialist writings, that man by nature likes to work and collaborate with fellow workmen. It is the bad organisation of society and the unjust distribution of the fruits of labour, that urge many individuals to linger when they have to work. Followers of Fourier established two Phalanstères in France and 28 in the United -States. Strife and ageing of their members brought about the dissolution of all co-operatives .

When after the French revolution of February 1848 a republican government under the direction of the poet Alphonse de Lamartine (1790-1869) took office, Louis Blanc(1811-1882) managed to create two producers' co-operatives, one for tailors and the other for saddlers. These co-operatives worked for the French army.

After the failed revolution of May 1848 a right wing government took office, and in the end the new president Louis Napoleon Bonaparte(1808-1873), as

emperor, succeeded in creating an authoritarian regime.. The co-operatives of Louis Blanc no longer received orders and were dissolved.
The socialist dream of a new economic order with workmen's co-operatives as the main theme was over.

3. From revolutionary socialism to social democracy and from right wing liberalism to radical liberalism (1850- 1920)

In France on November 7 1852 Louis Napoleon, was proclaimed emperor as Napoleon III. He obtained a great popularity by the introduction of general voting rights and the establishment of hospitals, children's homes, asylums for old persons and other social institutions. Being a convinced liberal he tried to conclude trade agreements with neighbouring countries . This policy succeeded well and brought about a general improvement in the living conditions of the French population.
The discovery of new gold mines in the United States and Australia brought about an extension of the gold reserves of the main industrial countries. In France it permitted the creation of enough money for the extension of industrial and commercial activities.
In such a situation socialist schemes had no chance of finding many supporters.
Karl Marx(1818-1883), a young German lawyer, who had fled to Paris, concluded from the failure of the producers' co-operatives that the workmen would never be able to manage their own factories . He was convinced that the only alternative for a capitalist society was an authoritarian state managed by intellectuals .
Under the influence of the dialectical philosophy of Friedrich Hegel (1770-1831) and the more materialistic theories of Ludwig Feuerbach(1804-1872) he believed that the development of society is determined by the economic evolution. As new economic activities developed new social classes emerged. These acquired consciousness of their material interests and opposed the ruling class with ideas, that formed an antithesis to the thesis of the traditional rulers. A class struggle set in and in the end some members of the new class succeeded in conquering powerful positions in society . Together with the old elite they developed a synthesis from elements of the thesis and the antithesis.
During the feudal period the nobility, as the reigning class, based its right to rule on its possession of the virtues of chivalry. With the development of international trade in artisanal products a new rich bourgeois class grew. It claimed a part in the political power in order to defend its economic interests.

After the French revolution the bourgeoisie became the ruling class, but adopted many ideas from the thesis of the nobility such as those connected with heredity.
In his book "Misère de la Philosophie "(1847) and in "Manifest der kommunistischen Partei " (1848), a paper that Marx published in collaboration with his friend Friedrich Engels (1820-1895), Marx insisted that industrial development had created a new social class" the proletariat ". Members of this class would with the help of intellectuals formulate an antithesis and finally by means of a revolution seize political power.
In February 1848 a bourgeois revolution broke out in Baden against the political power of the grand-duke. This spread rapidly and in all the German states kings and princes had to give in and accept liberal prime ministers. Marx went to Cologne and worked as a left wing journalist of the "Neue Rheinische Zeitung". He hoped that the workmen would organise and claim political power. However, the industrial proletarians had no organisations and no leaders. Most liberal politicians were insufficiently prepared to exercise political power. In June 1848 the Prussian army restored the absolute power of the kings and princes in all the German states. Marx fled to Paris and later to London.
There he worked as a reporter of European events for the "The New York Daily Tribune " and during his free hours he studied history and economics .In June 1851 he published his book " Zur Kritik der politischen Oekonomie .".Later he doubted the value of that book. It did not give a satisfactory version of his opinions. He started a more extensive work . In 1867 he published the first volume of "Das Kapital " Like Ricardo he was convinced that the relative values of goods are determined by the number of working hours necessary for their production. The entrepreneurs pay wages which are lower than what the workmen as value produce. In this way the various firms realise a surplus-value. All the surplus-value produced in an economy is divided under the capitalists in proportion to the invested capital . As a consequence prices are not proportional to the natural value of the various goods. Economic progress increases the capital that is invested in the various productions and reduces the amount of labour that is required. Marx concluded that as the global amount of surplus-value will decrease and the amount of capital will rise the profit rates must go down. This would cause serious recessions and more unemployment. In the end the working classes would no longer endure hardship and by means of a "proletarian revolution " they would destroy the capitalist economy.

Marx ' catastrophy theory contained a paradox. How would an impoverished "proletariat" be able to buy the necessary weapons for realising a successful revolution. Believing in such a possibility meant political dreaming.
In Germany two followers of Marx, Wilhelm Liebknecht (1826-'1900) and August Bebel (1840-1913) founded in 1869 a socialist party with a Marxist program. However, when this small party united with another socialist movement("Der allgemeine deutsche Arbeiterverein ") and organised a congress in Gotha, the participants adopted a program with proposals to reform capitalist society. Marx protested, but the leaders of the new party realised that the great majority of labourers wished an improvement of their living conditions and were not inclined to prepare a revolution.
Nevertheless, Bismarck did not trust the German socialist movement . Its internationalism was irreconcilable with his desire to create a powerful German state . The S.D.A.P(Sozial demokratische Arbeiterpartei) was forbidden . Its leaders had to flee to Switzerland.
Bismarck found the necessary inspiration for the development of a system of social legislation in the proposals of the economists of the Young historical school.
Most of these economists were ex pupils of Karl Knies (1821-1898), professor first at Freiburg and afterwards at Heidelberg. In his book "Die politische Oekonomie vom Standpunkt der geschichtlichen Methode"(1853) he denied the existence of general economic laws. Each economic phenomenon has to be explained by prevailing traditions and circumstances .
Under the influence of the German philosopher Friedrich Hegel (1770-1831) Knies considered the state as the incarnation of the economic and ethical aspirations of the nation. He was convinced that state intervention was a necessity each time private initiatives opposed such aspirations.
His followers established on 5-6 October 1872 at Eisenach " Das Verein für Sozialpolitik "
They promoted social legislation in order to improve the living conditions of the labouring class Bismarck followed suit. By imposing measures to better the life of the workmen he hoped to stop the dissemination of socialist theories.
However, due to a constant increase in the number of German industrial workmen and the economic recession the popularity of the German socialist party increased and its revolutionary character was strengthened.
Some German intellectuals were interested in Marx' work and tried to develop further his theories and apply them to current situations.

Rosa Luxemburg(1870-1919) stated in her book " Die Akkumulution des Kapitals"(1913) that as a consequence of the low wages entrepreneurs did not have a sufficient outlet for their products. They tried to sell the surplus in the colonies. Moreover, they realised important investments in these dependent countries in order to increase the production of the basic materials and agricultural products, they could sell in the home countries . In this way they created incomes, which made possible the purchase of products of the home country .

As a consequence the basic principles of capitalist production and commerce were spread over the whole world.

Rudolf Hilferding (1877-1943) developed in his book " Das Finanzkapital" (1910)the idea of a cumulative process leading to more and more economic concentration. Marx had always claimed that in a capitalist economy free competition determines prices and wages. Hilferding pointed out that in various branches of the economy, cartels determine prices, which are applied by all the members of those organisations. As a rule the firms concerned realise higher profit margins than the firms operating in a competitive market. Therefore most entrepreneurs will try to become members of a cartel. The big participants of such organisations try to exclude competition by buying the equity of their competitors. The necessary funds are as a rule procured by big banks. In this way these banks obtain seats in the councils of the cartelised firms. Finally almost the whole industry of the various countries would be under the control of a single big bank. Hilferding concluded that in the distant future socialist parties would be able to take over the direction of the industrial structures of the different countries by nationalising that single big bank. Hilferding's political dream was not realised. He lost sight of the fact that in the Germany of the beginning of the twentieth century a militarist minority of "Junkers' exercised much influence on daily politics. In 1890 anti-socialist legislation had been suppressed and the S.D.A.P.(Sozialistische Deutsche Arbeiterpartei) became after each election more powerful in the German parliament . However, it was not able to resist the influence of the "Junkers". These convinced the German government that a war with Russia was a necessity in order to slaughter the Russian bear before he became too powerful.

The leading members of the S.D.A.P. were convinced that a conquest of Germany by the Russian totalitarian state would mean the end of their party . Therefore they approved the war-credits claimed by the German government. They did not realise that they had handed over the whole direction of daily affairs to the Junkers class, who controlled the German army.

After the defeat of Germany, the S.D.A.P.played a leading role in the democratic governments, which took over the direction of the German state. However, they inherited a ruined economy and were confronted with the excessive financial claims of the allies. In such a difficult situation they had to work together with the other democratic parties in order to assure a minimal living standard for the German population. As collectivisation of enterprises was resisted by all liberal and right-wing parties, they could not realise their collectivist dream .

In France the transition from a revolutionary socialist party to a social democracy started already at the end of the nineteenth century . The way to a reformist socialism was prepared by the Bonaparte's tradition of state intervention in the market economy. Napoleon III had no clear project for the transformation of capitalist society, but he wished to mitigate the contradiction between extreme richness and extreme poverty by creating public services. This idea was further developed in the books of some French professors.

Michel Chevalier (1806-1879) lectured on political economy at the" Collège de France". In the second part of his course he asserted that economic progress was the consequence of the combination of two forces .Economic freedom fosters the creation of new firms by private initiative. The need for order entails state intervention . A society without economic liberty would be petrified . In case of absence of state intervention society would become chaotic, which would impair a harmonious development.

Paul Cauwès (1843-1917) defended the creation of important public enterprises . He upheld the establishment of public railways. He asserted that a coherent railway system could not be realised by private initiative, because some parts of the trajectory would not yield sufficient benefits .He said that when services, needed for economic and social development, could not be delivered by private initiative, the state had to step in.

These ideas prepared the way for the development of a peaceful reformist socialism.

After the failure of the Commune (1871) reviving French socialism lacked unity. There existed many factions . Some leaders like Jules Guesde (1845-1922) and Paul Lafargue(1842-1911), the son in law of Karl Marx, wished to establish a party that could prepare a proletarian revolution. Others such as the physician Paul Brousse (1854-1912) wished to develop a gradual socialism by taking over private enterprises. In 1883 he published his book "La propriété collective et les services publics ". He believed that the

socialists had to take part in municipal elections in order to stimulate local and regional initiatives to take over essential public services .
In 1885 Benoït Malon (1841-1893), an ex-Communard, who had fled to Switzerland and later to Italy, created on his return to France, a society for socialist research. He attracted young intellectuals, who were interested in social reform. Some became parliamentarians as independent socialists .
When Pierre Waldeck-Rousseau (1846-1904), a convinced republican, became prime minister in June 1899 he invited the socialist Alexandre Millerand to become minister of commerce and industry. Millerand accepted and brought forward a programme of labour reforms . He was attacked by anarchist and marxist socialists, who were convinced that " Un ministre socialiste, n'est plus socialiste ".
However, his action was defended by moderate independent socialists . One of them Jean Jaurès (1859-1914) succeeded in unifying in 1905 most socialist fractions in one party.: "La section française de l'internationale ouvrière "(S.F.I.O).
Jaurès, was like Millerand a convinced supporter of reform. He believed that many members of the French bourgeoisie would for ethical reasons accept reforms, directed at relieving the living conditions of the poor. A convinced anti-militarist, he realised that the growing antagonism between France and Germany could lead to a devastating war. Therefore he sought a friendly relation with the German socialists. The name, he gave to the socialist party was a symbol of his internationalist ideals. He mistrusted the good relations of France with Russia, because this alliance was directed against Germany. . He hoped that by organising a general strike the German trade unions would prevent a mobilisation of the German army. However, at the Stuttgart Congress of the Second International(1907) the German delegation refused the inclusion in the conclusions of the congress of any reference to a general strike as way to impose the maintenance of peace. Jaurès' socialist internationalism was but a political dream He was murdered by a French nationalist on 31 July 1914, On August.2 German troops entered French territory. The first world war had started.
After the war the S.F.I.O. split at the Congress of Tours (1920) into a communist group, which became a member of the Third International and various socialists groups ,which refused to accept the dictates of Moscow. They rebuilt a reformist socialist party. The Comintern required complete obedience of the French communists to directives, that only served the interests of the Soviet Union. It claimed that the French trade union movement should be subordinate to the party Most trade union leaders could

not accept such subordination and by 1926 the membership of the socialist reformist party was more than twice that of the communists.
In Great Britain , during the second half op the 19th century the political struggle between the liberals (the Whigs) and the conservatives (the Tories) motivated both parties to increase their popularity by according more rights to the middle and the lower classes.
The British liberal economist John Stuart Mill (1806-1873) criticised the pessimistic theories of Malthus and Ricardo. In his" Principles of Political Economy" (1848) he contested the theory of Malthus that an increase of the population would cause towering food prices and aggravate the poverty of the lower classes. He cited the example of the Flemish peasants, who by a well conceived succession of the diverse cultures and heavy dressing with manure, succeeded in obtaining great quantities of food on a limited number of acres. He denied that the mechanisation of industrial production would cause unemployment. When the number of consumers increases the entrepreneurs can expand their production . This raises productivity and wages. Higher wages create more demand for goods and services, so that the number of jobs will not decrease. In 1865 Mill was elected member of parliament. He presented a draft to extend the suffrage to all men and women, and another to introduce primary education for all children.
Few MP's were interested in his progressive plans. Disgusted he found that most members of parliament were " diminutive politicians" . They had no desire to better the living standards of the majority of the British population.
However, in 1867 the conservative prime minister Benjamin Disreaeli lowered the franchise for the population of the towns. The electorate was almost doubled
The liberal prime minister William Eduard Forster (1818-1886) introduced in February 1870 an education bill ,which became law in August 1870 and made primary schooling obligatory for all children.
In the mean time, due to the growth of trade-unions and co-operatives the living standards of the British working classes were raised . At the end of the century there was a general evolution of public opinion to a more radical liberalism. This also became manifest in the theoretical treatises. Alfred Marshall (1842-1924), professor at the university of Cambridge was considered as the most important economist of the beginning of the twentieth century. His book " The Principles of Economics "(first edition 1890) was regularly revised by the author and reprinted eight times. His prestige was so important, that many economists thought it was no longer possible to find new economic theories ." It was all in Marshall ! "

Marshall was convinced that in economics exact methods could be used because needs, production and incomes could all be measured in money terms To measure the importance of desireability he used the "marginal theory ".This theory had been almost simultaneously formulated by some English (William Stanley Jevons(1835-1882)) Austrian (Carl Menger (1840-1921) and French (Léon Walras (1834-1910) economists .It starts from the idea that the subjective value of a good is determined by the utility of the unit, which is available for the least important use. When a person disposes of a certain income he will start buying the goods, which he judges most important .He will use his last £ for buying a less important good. It is the utility of that good, which determines the value of his money .As a consequence when a poor person loses one £ he will suffer more than a rich person losing the same amount of money.This justifies the introduction of progressive taxation.

Many liberal politicians were not unwilling to apply more progressive taxation. In 1909 the liberal chancellor of the exchequer Lloyd George(1863-1945)issued " a people's budget".

Death duties and income tax were increased . Moreover a super tax was introduced on incomes above £ 3.000. The return of all these taxes was used to pay for an extension of the British fleet and for financing a system of state pensions for all citizens.In 1911 Lloyd George pushed through parliament "The National Insurance Act". This law was an imitation of the German law of 1889. It insured all labourers in private firms against the consequences of illness and invalidity.

The liberals realised such important reforms because they were convinced that in the rich British society of the beginning of the twentieth century it was no longer acceptable to let unfortunate people live in extreme poverty. Moreover, they feared to lose votes to the "Labour representative Committee", which had separated itself from the liberal party, because it found the reforms insufficient. This embryo of a socialist party was supported by the majority of the British trade unions. As a consequence its purposes were purely reformist. Although Marx had passed the greater part of his life in England, he had found there few adherents. Revolution seemed superfluous in a society which was on the move to peaceful reforms.

4. Capitalism in crisis : from the First World War till the end of the Vietnam war .

From 1895 till 1914 a booming economy prevailed. This was a consequence of a series of inventions, which produced new industries in the fields of electricity, communications, new materials, chemical fertilizers and medicines.

Marx had predicted a collapse of the capitalist system as a consequence of a severe crisis. Such a crisis did not manifest itself.

In 1912 the Austrian economist Jozef Schumpeter(1883-1950) published an important book, namely " Theorie der wirtschaftlichen Entwicklung". He was convinced that economic progress was a consequence of the initiatives of entrepreneurs. They devise new products, new methods of production and management. Moreover they explore new markets and develop the cultivation of tropical plants and the exploitation of mines in foreign countries. All these activities can be classified as " innovations ".As a rule they result in the realisation of higher profit margins than are usual in the traditional industries. Other entrepreneurs will follow suit and act as "imitators" of the successful innovators. The necessary capital for all these new enterprises is delivered by capitalists and rentiers ,who will invest their amassed savings, and by the creation of money by the banks. The demand for labour increases . New incomes are created and in the end the economy is "overheated". Demand in most branches exceeds productive capacity. Prices increase and there is a lack of capital to go on financing new initiatives . The banks have no longer enough guarantees to create great quantities of new money. They raise interest rates in order to limit the demand for credit and increase their profits All enterprises are confronted with a growth of their costs. Many traditional enterprises, which realised but a moderate rate of profit, can no longer sustain this increase. They go broke . These bankruptcies cause great losses to their suppliers and the dismissal of labourers. Many persons reduce their consumption because they fear losing their job. Demand for goods and services decreases. A recession sets in, which is necessary in order to adapt the productive capacities of the nation to the new technical and sociological demands and opportunities. When this adaptive process comes to its end a recovery of the confidence in the circles of financiers and entrepreneurs sets in. New investments are made and a phase of economic recovery prepares a new economic boom.

Marx was convinced that depressions prepare the collapse of the capitalist system. Schumpeter considers them as temporary unfavourable interludes in the development towards greater prosperity.

His political dream of a favourable evolution of the capitalist system received a serious blow when the first world war started in August 1914. Schumpeter had ignored the fact that within the capitalist system large parts of the political and economic elites had adopted extreme nationalist visions. This made a war between various European nations inevitable.
In 1917 the imperial regime in Russia collapsed. In November of that year a communist regime took power in most Russian towns. After four years of civil war the communists were master of the whole of Russia. Their leader Lenin(1870-1924) had in his book "State and Revolution" (1917) foreseen that after the proletarian revolution a limited number of communist party members had to exercise a totalitarian regime. He claimed that this was necessary to eliminate bourgeois culture.
The communists had promised that landlords would be expropriated and the peasants would become proprietors of the land they cultivated. Lenin had to honour that promise. The direction of the industrial firms was entrusted to councils of labourers, in which members of the communist party occupied a paramount position. This communist dream state ended in complete anarchy .The councils were not able to resolve the numerous problems of production and organisation in a country impoverished by a long disastrous war. The government had to print much money to pay its employees and the officers and soldiers of the red army. .The scarcity of industrial products combined with the great amount of paper money led to a huge inflation. As they could not buy much with the money they received for their crops, the peasants were not motivated to produce more than they needed for feeding their own families. There was a lack of food in the markets. Members of the communist party had to organise expeditions of industrial workmen to the country-side in order to acquire by force the needed agricultural products.
In March 1921 Lenin introduced a new policy (the NEP = New Economic Policy) .
As far as they had survived the revolution, the ex-bourgeois entrepreneurs recovered their positions of manager of their firms However, they had to work under the supervision of a member of the communist party. In the agricultural sector the majority of the peasants had to become member of a co-operative, which bought the necessary machinery and raw materials and organised the sale of agricultural products. The NEP brought about a recovery of the economy, but entailed many unsound situations. A small number of NEPmen could enrich themselves and live in a way irreconcilable with communist ideals.

Lenin died on January 21 1924. In the central committee of the party three different options to reform the economic system were proposed :
1.The agriculturist view : Nikolai Kondratieff (1892-?) and Gregory Sokolnikov (1888-1939) proposed to increase agricultural production in such a way that large quantities of grain and other food-stuffs could be exported. However, after the failure of the Spartakist revolution in Germany and the defeat of the Soviet army in the wars in Poland and the Baltic states, it was evident that a neo-physiocrat policy would make the Soviet-Union industrially dependent on the goodwill of capitalist nations. Therefore the majority of the members of the central committee didn't accept neo-physiocratism. During the dictatorship of Stalin many neo-physiocrats were arrested and murdered. Of the reputed economist Nikolai Kondratieff, we do not even know the date of his decease.
2. The theory of genetic development : This theory stipulates that the natural development of an economy is realised in three stages. Agricultural production and the treatment of plants and animals with the purpose to produce food and basic materials for the clothing industries are first organised. During the second stage the industries. necessary for the production of durable consumption goods are created.. At the end of this stage the nation can provide the citizens with all the goods they need. By exporting consumption goods it obtains the necessary financial resources for the purchase of industrial equipment and foreign raw materials. The third stage is focused on the development of heavy industries, which can procure the machinery and basic materials needed for the production of consumption and investment goods.
Some former Mensheviki like Wladimir Groman(1873-?) and Wladimir Alexandrovich Bazarov (1874-1939) defended this theory.
At first Stalin (1879-1953) seemed convinced that this was the best way to develop the Russian economy. He used this theory as an alternative for the propositions of Trotzki(1879-1940),who in the Central Committee defended the creation of heavy industries. Trotzki was convinced that this was necessary in order to produce the armaments Russia needed to resist an attack by the capitalists. When in 1927 Trotzki was banished and fled to Turkey and later to France, Norway and Mexico, Stalin felt no longer the need to defend genetic development.
The stagnation of agricultural production and the insufficient deliveries of food to the towns convinced him, that the application of genetic development ended in failure.

The former Mensheviks, who wished to practice a humane method of economic development, were discredited and most of them were arrested and died in prison.

3.Applying teleological planning. The theory of teleological planning was defended by Stanislas Strumilin(1877-1974) during the years 1926-'27. He stated that without the creation of some heavy industries economic development would be impossible. Patrick .Feldman (1893-1936) constructed a growth model with two sectors, one for the production of consumption goods and one for the production of capital goods. He proved that a rapid development was only possible if all the surplus value was invested in the production of capital goods. At first Stalin opposed teleological planning but in 1928 he changed sides. On October 1 of that year started the first "Five Years Plan". The peasants had to transfer all their land and cattle to co-operatives ('The Kolkhozes).Those who refused were arrested and sent to work camps. The kolkhozes sold the greatest part of their production at low prices to the state and to consumers' co-operatives. In this way the living standard of the peasants was lowered and many peasants emigrated to the industrial centres, where they found work as labourers . As food was cheap, wages could remain low and great quantities of basic materials and machinery could be produced at low cost.

The first five years plan was realised in four and a half year. In this short period the production of electricity was increased by 150 percent and that of machinery by 300 percent.

The production of consumer goods remained very limited. In Moscow it was almost impossible to find new furniture. Therefore the second five years plan was more directed towards the production of consumption goods . However, when the third plan started in 1937 the Soviet Union was confronted with German rearmament and regular verbal attacks of Hitler against communism. Therefore this plan was directed at the creation of heavy industry and the production of weaponry in regions situated eastwards of the Ural mountains. Later this proved to have been a wise decision. During the second world war the Germans captured the greater part of the heavy industries in the western part of Russia. The soviet army had to rely on armaments and ammunition produced in the factories in the eastern part of the country.

The results of soviet planning made some impact on economic thinking in Europe and the United States. There a recession had degenerated into a grave depression. In the most important industrial states such as the United States and Germany millions were on the dole. Three kinds of solutions were proposed by the economists of that period namely :

1) Deflation : The adherents of this solution believed that the crisis was a consequence of the excessive rise of prices, wages and interest rates during the boom of the years 1926-'29. High interest rates decelerated investment and high wages and prices limited the possibilities of exporting the national production. In order to lower the interest rate the government had to balance its budget so that the state could limit its demand for money in the capital market. As due to the crisis the demand for private investment was very low a strong decrease of the interest rate would follow. Such a decrease would bring about a resumption of investment and a general recovery. The crisis had already caused a decrease of prices and wages so that investment could be realised at low cost.
In Belgium such a deflation policy was applied by the catholic-liberal government of Charles de Broqueville (Oct. 22 1932- Nov. 13 1934). This government introduced a crisis tax in order to balance the budget. Such a tax diminished the demand for consumption goods and aggravated the crisis. On November 20 1934 another catholic–liberal government was constituted under the direction of George Theunis (November.20 1934- March 19 1935). This government tried to compensate the loss of exports by an increase of some production (for example of coal) for the domestic market. In order to limit failures the government issued the enactment of December 7 1934. It gave to a majority of the producers of a group of products the possibility to determine the prices that had to be applied by all the firms of that branch. This measure was in contradiction with the deflation policy. Instead of letting the prices fall further, the government gave power to the most important firms to stabilise them.
In the mean time some big industrial nations like the United States and Great Britain had devalued their currency in order to fortify their competitive position on the world markets Belgium followed this example on March 30 1935. The Belgian franc was devalued by 28 percent. This made the resumption of deflation impossible . All imported products became more expensive. The Theunis government which had tried to defend the value of the Belgian currency had resigned on March 19, eleven days before the devaluation.

2)The application of economic planning. The idea of economic planning dates from the first World War. Walther Rathenau (1867-1922), the son of a rich German manager had been appointed head of the service for the

recovery and distribution of basic materials . He discovered that regular consultations of the involved managers of the diverse firms permitted planning investments and production in such a way that unnecessary extensions of certain branches could be avoided . In his books " Von kommenden Dingen"(1917), "Die neue Wirtschaft "(1918), "Nach der Flut " (1919) and "Die neue Gesellschaft "(1919) he proposed establishing trade organisations and industrial agencies .The trade organisations would distribute orders among the enterprises. The industrial agencies would analyse the development of economic markets and plan new investments . All firms would sell products at cost prices to the trade organisations, which would enjoy a monopoly in the diverse markets.
In order to avoid abuses and excessive rises of prices, the pricing process would be controlled by a commissioner of the ministry of economy.
Rathenau's proposals were well received by Rudolf Wissel (1869-1962), who as minister of economy submitted them to the Reichstag for approval. A Reichwirtschaftsrat ("State Economic Council ") was created, but the resignation of the government meant that the other organisations necessary for the realisation of economic planning were not installed.
In the following government the social-democrats had no majority and the liberals opposed any idea of economic planning .Moreover, the diverse German governments of the twenties were confronted with serious financial difficulties. They had to finance heavy reparation payments to their opponents in the first world war. There was no room for profound and costly reforms of the economy. When in July 1932 the world crisis brought the German economy to a state of collapse the idea of economic planning was brought to the fore . The leaders of the German socialist trade union published in July 1932 a project of economic planning prepared by a work group under the direction of Wladimir S. Woytinski(1885-1960), Fritz Tarnow (1880-1951) and Fritz Baade (1893-1974). Woytinski was a reputed economist, Tarnow and Baade were parliamentarians of the social democratic party. In their project the nationalisation of the collieries, the steel and iron plants, the chemical and the cement factories, the most important means of locomotion, the banks and the insurance companies were proposed. The planning department of the government would design the necessary investments in the nationalised branches of the economy. The banks and the insurance companies would assure that the necessary financial means would be provided.

The German social democratic party saw no chance of realising such an ambitious plan in a democratic way. However, it could not prevent the continuous increase in the number of men out of work.
Adolf Hitler succeeded in acquiring great popularity with his criticism of the Treaty of Versailles. He held that treaty responsible for the hardships of the Germans.
The German government obtained on July 9 1932 at the Conference of Lausanne that it no longer had to continue its reparation payments. The French government protested but the British and American governments were convinced that Germany could no longer support such a heavy drain. British industry hoped that by abandoning the reparations they would be able to resume their exportations to Germany. American statesmen considered the ending of the reparation payments as the only way for the American enterprises to recuperate a part of their investments in German industry.
However, it was too late to stop the electoral successes of the Nazi party. In the parliamentary elections of July 31 1932 Hitler's party won 230 seats and became the greatest party in the German Reichstag. President Hindenburg refused to appoint Hitler as chancellor. New elections were organised on November 6 1932. The Nazis lost some seats, but they remained too strong to permit the formation of a government without the participation of their party or of the communists.
Franz von Papen(1879-1969) a right wing catholic, succeeded in convincing Hindenburg that he had to install Hitler as chancellor of a coalition government of the Nazis and right-wing parties. On Januari 30 1933 Hitler was appointed as chancellor. As also the ministry of home affairs was put in the hands of a Nazi minister, Hitler could control the German police,. who were ordered not to intervene when SA and SS storm troops destroyed the socialist co-operative and mutualist buildings. Socialist and communist members of parliament were arrested and sent to labour camps. In the spring of 1933 Hitler had succeeded in eliminating by this brutal method all opposition to his political power. He introduced a four year plan to resolve the problem of unemployment and prepare the reorganisation of German industry. Many unemployed persons were mobilised for the execution of great public works. The heavy steel and chemical industries received big orders for the rearmament of Germany. The problem of unemployment was solved but the majority of Germans had to live with a low income.
In Belgium Henry De Man (1885-1953)designed with the help of Albert Halasi ,a Jewish Hungarian economist ",a scheme of a Labour plan ".On Christmas day 1933 it was approved by a congress of the Belgian Labour

Party .and 22 commissions were installed to work out its details. It contained many proposals which were copied from the plan in 1932 published by the German syndicalists. Probably this was a consequence of Henry de Man's stay in Germany during the years 1929-'32. He was a professor of social psychology at the university of Frankfurt am Main. The nationalisation of the basic industries, the creation of a commissariat for the co-ordination of all transportation services and a national institute for the control and co-ordination of the banking operations..were included in his plan. Moreover, a service for the organisation of economic .recovery would be installed. The commissioners of these diverse institutes and services would attend government proceedings as ministers without portfolio.

After the demission of the Theunis government, a coalition of the three dominant parties took office under the direction of Paul Van Zeeland (1893-1973). De Man was appointed minister of public works and reduction of unemployment. The profits made by the Belgian state as a consequence of the devaluation were used for the execution of a great number of public works. This led to a decrease of unemployment . Moreover the general recovery in the world economy created opportunities for export and this too brought an increase in the number of jobs. This gave the impression that Belgian economic planning was successful, but in fact the structural reforms devised in the plan of de Man were not realised. The catholic and liberal members of the government refused any idea of nationalisation of private firms. When in 1938 the world economy was confronted with a new recession unemployment again increased.

Nevertheless, the success of Belgian planning had as a consequence that the idea of economic planning found many adherents in the socialist parties of France and the Netherlands After the Second World War in both countries and also in Norway planning departments were established. In the Netherlands the famous Dutch economist Jan Tinbergen (1903-1994) was appointed head of the planning department. His collaborators designed a series of mathematical functions, which permitted the prediction of the evolution of the main macro-economic magnitudes. Such planning was very useful for stipulating the desirable economic policy, because the financial means ,which would be put at the disposal of the government in the coming years could be predicted. Moreover, it was possible once the planned outlays were made to predict the economic consequences of the financial policy applied.

In France the "Commissariat du Plan" was created by George Monnet(1888-1979) in 1946.. Monnet had participated in the planning of British

production and distribution of raw materials and labour during the Second World War. His methods of planning were different from the Dutch method. They were directed at the realisation of the production of goods and services, which were estimated as being necessary for the reconstruction of the French productive system.
In Belgium economic planning was introduced in 1959. In that year " The Bureau for Economic Programming " was created.. In 1970 it was renamed " The Bureau for Economic Planning ". However, due to the open character of the Belgian economy it is very difficult to anticipate the future evolution of the main macro economic magnitudes. Therefore the Bureau has to revise its predictions regularly.. This reduces the value of economic planning for designing an efficient economic and financial policy.
The dream of stabilising economic growth by means of economic planning is over.

3) The introduction of a new economic and financial policy.
Most traditional economists considered economic planning as too rigid a system to be able to guarantee a satisfactory economic development. They were convinced it was preferable to let the managers of the various firms free to avail themselves of the opportunities for realising profits by adapting the production to the various demands in the markets. Therefore they sought a solution for the great depression of the thirties by introducing a new financial policy . Instead of increasing taxes in order to balance government budgets they suggested that during a depression the government should increase its outlay in order to create a greater demand for goods and services.
The most important and original author of that period was John Maynard Keynes (1883-1946.) The son of a tutor, afterwards registrar of the University of Cambridge, Keynes studied mathematics and economics at King's College in Cambridge. He was appointed a lecturer in economics on a recommendation of the then famous economist Arthur Cecil Pigou(1877-1959), one of the defendants of a new financial policy. In 1915 Keynes became an official of the British Treasury. As such he participated as financial expert in the peace negotiations in Versailles. He did not agree with the excessive reparations imposed on the German nation. On June 5 1919 he took his leave. In the summer of that year he wrote his book "The Economic Consequences of the Peace". He insisted that Germany would not be able to pay such a huge amount, and that such financial transfers would ruin the productive capacities of the German economy. This would have a very unfavourable influence on the whole European economy. This book made an

enormous impression on British academic and commercial circles. Keynes became a reputed economist. In the following years he regularly published articles and some books on English politics and general economic theory.In March 1933 he wrote four articles for the famous newspaper " The Times "on the diverse economic and financial measures, which would bring about economic recovery. In 1936 he developed his proposals in a more theoretical book, namely " The General Theory of Employment, Interest and Money ".It is a very original work, but it is not always easy to understand Keynes' theories. The central theme of his reasoning is the relation between consumption, investment and saving. He distinguishes the ex-ante and ex-post values of these big economic entities. . If we use Y as symbol for the national income, S for global saving and C for consumption at the end of each period $Y = S + C$. In this relation S represents all income which is not used for consumption . This means that the income used for purchasing investment goods is also contained in S. The total demand is equal to $C + I$.. In that relation I symbolises all investment outlays. At the end of each period the total demand, which was satisfied is equal to the created income. $C+I = C+S$ or $I=S$.

However at the beginning of each period planned investment may differ from planned saving . If it is greater than planned saving, total demand for goods and services will exceed total production.. The diverse firms will increase their production and eventually also their prices so that in real and in nominal terms the national income will increase. .A part of that greater income will be saved. As a consequence ex-post saving will exceed ex-ante saving. Ex-post investment will normally be smaller than ex–ante investment because due to insufficient productive possibilities not all planned investment will be executed . This explains why ex-post S will be equal to ex–post I. If ex-ante saving exceeds ex-ante investment the offer of goods and services will be greater than the demand and national income in nominal terms will decrease. S will decrease too .At the end of the period it will again be equal with I. .

With this reasoning Keynes proves that Adam Smith was wrong when he stated that the greater the amount of saving the higher will be economic growth. More saving will only promote economic growth if it leads to an equal increase in investment. If saving grows more than investment a recession will follow, due to a lack of demand. Such a recession is a cumulative process for when demand remains smaller than production, diverse firms will dismiss some members of their work force. The fear of losing their jobs will motivate many members of the working class to reduce their consumption. Capitalists will fear that some enterprises will lose

money and will no longer be able to pay dividends . Therefore they will reduce their investment. Large amounts of money will remain idle in the banks and a general depression will follow.

In order to avoid such a dismal evolution the state should increase consumption and investment by lowering taxation and increasing its outlay for public works and social subsidies. As a consequence a budgetary deficit would be unavoidable. Such a deficit would be financed by bank credits and the emission of government bonds.

The traditional liberal economists condemned such a policy because it causes an increase in interest rates . This makes investment more expensive and will decrease private investment They assert that whereas the state will invest more the private sector will invest less .

In order to avoid an increase in interest rates Keynes defends a "cheap money policy." The central bank would allow large credits to the private banking sector, which would be able to finance at low interest rates public and private outlays.

Keynesian politics have important social repercussions. They favour the interests of the working class as they increase the demand for labour. They reduce the income of the rentiers, who will receive less rent on their capital .Moreover, by increasing the demand for goods and services Keynesian politics enhance the price level .The rentiers would lose a part of the buying power of their money and would not be sure that this loss would be compensated by the interest they would receive on their deposits and bonds.This explains why Keynesian theories were well received by the majority of left wing politicians but found few adherents in the circles of conservative politicians and financiers. However, in the thirties the repercussion of the crisis on the living standard of the working classes was so terrible that something had to be done to avoid bloody rebellions. Already before the publication of Keynes' articles in "The Times" the American president Franklin Roosevelt (1882-1945) applied a policy ,which was akin to that proposed by Keynes . Roosevelt's "New Deal 'started in the spring of 1933 by devaluing the dollar and spending a lot on public works. Prices were stabilised by means of agreements between the main producers. This put an end to the "cut throat competition " which had caused the failure of many American companies. Trade unions were stimulated to make collective agreements with the entrepreneurs in order to guarantee good wages for their members and in this way promote consumption The "New Deal' policy caused great budgetary deficits. Republican politicians accused Roosevelt of raising the debt .of the American federal state.. On December 1933 Keynes

published an open letter in "The New York Times" to the president in which he defended the policy of big government outlays. He was invited by an American university to come to the states . In May-June 1934 he visited Washington and engaged in conversations with higher officials .However, he was not received by the president.
The American democrats did not like him because he had in his book " The Economic Consequences of the Peace "criticised the democratic president Thomas Woodrow Wilson(1856-1924) . Keynes had accused Wilson of weakness in his attempts to bring about a more honest and practicable peace treaty with Germany .Keynes' stay in America increased the interest of many young American economists in his work. He found many American epigones. of whom Paul Samuelson (°1915) is the most well known. In 1970 he received the Nobel Price for his extensive work.
In England John Hicks (1904-1989) devised in an article "Mr Keynes and the Classics – a Suggested Interpretation ",which was published in the journal " Economica" of April 1939, a scheme which took account of the classical and the Keynesian views of the causes of economic growth and depression. This was the starting point of a new economic school "the Neo-Keynesians " . They tried to prove that the economy could reach a state of equilibrium when the interest rate was such that ante-investment was equal to ante-saving. In order to mitigate fluctuations the government had to keep the money creation in such limits that inflation remained low and full employment was nevertheless realised. This was feasible by what was called " fine tuning ". When inflation increases the money creation would be reduced, so that the demand for goods would decrease. When unemployment goes up ,the banks would receive more credits from the central bank so that they could deliver cheap loans for new investment.
Neo-Keynesian economics were practised by many European governments during " The happy sixties" They seemed to guarantee the possibility of stable economic growth with almost constant full employment and low inflation. However, at the beginning of the seventies in most countries inflationary tendencies grew stronger. In 1973 the big increase of energy prices brought about such high inflation that the "fine tuning policy " could no longer guarantee economic equilibrium.
Among the many economic treatises based on Keynesian and Neo-Keynesian theories I must quote the book of the Belgian economist Alexander Lamfalussy (°1926) "Investment and Growth in Mature Economics- The Case of Belgium (1961)".Lamfalussy explains in this book that in a mature economy ante-saving regularly exceeds ante-investment . This brings about

domestic demand which remains smaller than domestic production. Fierce competition obliges firms to use the most efficient productive methods. This reduces cost prices . As a consequence many firms are able to compete on foreign markets .Exports exceed imports . The balance of trade closes with a surplus. As the profit margins of most Belgian industries are low many capitalists prefer to invest in foreign industries. .This brings about a new equilibrium. The surplus in the balance of trade is absorbed by a deficit in the capital account with foreign countries. Lamfalussy warned that in the long run Belgium was running the risk that investment in the Belgian industries would remain too low and would be excessively directed to traditional branches. Indeed that has happened during the seventies when the Belgian government in order to guarantee the survival of old industries gave large subsidies to steelworks, coalmines, shipbuilding yards and textile plants. These huge public outlays prevented a fierce crisis, but created a huge public debt ,which made an increase of taxation inevitable and limited foreign investment and the development of new industries.

Keynes had stated that during an economic boom the yield of taxes would increase in such a way that it would be easy to repay the loans emitted during a recession.
However, the increase of incomes creates a greater demand for public outlay. More people buy a motor car . As a consequence it becomes necessary to construct more and better ways in order to avoid congestion. Parents wish to extend the studies of their children. In order to satisfy the demand for more schools and teachers the government has to increase the outlay for education Disabled, ill and crippled people claim in a richer society more help and social subsidies from the community . This too increases the government's outlay. During the sixties most governments used their bigger income to satisfy the wants of their electors and repaid only a small portion of their debts. In Belgium at the end of the sixties the minister of public works J. de Saeger started a program of building a network of motorways , which was financed by public loans. As a consequence when in the years 1973-'79 the country was confronted with a serious inflation due to the excessive increase of energy prices, practising a Keynesian policy led to an excessive growth of the global public debt .The interest, which had to be paid on this debt made it almost impossible to balance the budget. Only by devaluing the Belgian franc in February 1981 could the weight of the public debt be reduced and the regular increase of it be ended. Countries such as France ,Great-Britain, Italy and Spain have also used devaluation as a way of

diminishing the weight of their public debt. Such policies discredited Keynesian methods to bring about a permanent growth of the economy.
Already in 1947 the American economist Milton Friedman (°1912) criticised in a lecture held at "The econometric society " the Keynesian theory that it was possible to obtain permanent economic growth by an expansive fiscal and monetary policy. He claimed that Keynesian policy promotes inflation, which after some years acquires a galloping character. Everybody tries to get rid of money, that is rapidly losing its purchasing power. Friedman insisted that to stop inflation the creation of money by the banks must not exceed what is needed for the normal extension of the production of goods and services. This lecture was the starting–signal for the monetarist school. It intended to stabilise prices, while the Keynesians wished to realise full employment. Moreover, these schools had opposite visions on the efficiency of econometrics.
Keynes had no confidence in econometric methods. He insisted that many psychological factors, which can't be measured, play a major role in the determination of the economic processes. Milton Friedman asserted that only by analysing these processes with mathematical methods can an objective economic theory be devised .
In politics he wished to limit the interventions of the state as much as possible. He asserted that free competition was the main source of economic progress and that the number of monopolies in the American economy was very low. Therefore the United States were the most efficient economy. In many European nations public monopolies impeded the development of private initiatives. Moreover, European states too often fortified powerful firms by permitting that they paid no or very low taxes on the profits, they used for acquiring more power by absorbing competitors.
During the seventies Friedman's political views found many adherents in the circles of American and European managers and right-wing economists. They complained that by not adapting the scale of taxation to inflation, the states confiscated an increasing part of the profits of private firms.
Not only the managers and capitalists complained about the increase of taxation, but also the great majority of the members of the middle class found their living standard debased by excessive taxation. As a consequence right-wing parties realised at the end of the seventies, beginning of the eighties electoral victories in major industrial nations like the United States and Great Britain.

5. The development of neo-capitalism and the globalisation of the world economy.

During the period from the end of the First World War to the end of the seventies the capitalist part of the world was shrinking, while the communist and socialist nations became more numerous. After the creation of communist states in Central and Eastern Europe, the victory of communism in China (1949) and the transfer to quasi communist systems in some countries of Asia(Vietnam, Cambodia, Laos, South Yemen) , Africa (Ethiopia, Angola and Mozambique) and Latin America (Cuba and Nicaragua) many political observers foresaw that in the end the capitalist system would disappear.
Many books were published about the methods practised to transform a capitalist system into a socialist one.
The defeat of the American troops in Vietnam debased the prestige of the United States.. Moreover, the enormous cost of this war undermined confidence in the value of the dollar. During the seventies the dollar was devalued repeatedly. This increased inflation in the United States.The majority of Americans believed that they needed a president with a strong character, who would re-establish order in the economy and assure America a leading position in the world. In November 1976 they elected the democrat Jimmy Carter(°1924) as president, because they had no longer confidence in the sitting president, whose efforts to deal with inflation and unemployment had switched policies several times. But Carter failed to solve the economic woes .Moreover, he could not avoid the staff of the American embassy in Teheran being taken hostage by militant followers of the Ayatollah Khomeini. An effort to free them by means of a surprise assault by an American commando failed miserably and created the impression that Carter was an inefficient manager In the mean-time some American economists had devised a set of economic principles they specified as " the supply side economics". They argued that the supply of goods and services is determined by their price . When the producers can obtain good prices they will increase efforts to extend production. High taxes diminish the net result of production and as a consequence reduce the supply. This leads to lower incomes and lower demand. Finally the vicious circle of downhill movements of production, incomes and consumption brings about general economic stagnation or even a recession. Therefore good government must include low taxation. The American economist Arthur B. Laffer (°1940) illustrated this idea with a curve (The Laffer curve).An increase of taxation procures

initially a higher public income, but once a certain ceiling is attained , higher taxes cause lower public income. In 1977, during the presidency of Jimmy Carter, republican members of the Congress formulated proposals for the reduction of taxation. However, the democrat majority rejected them, because they feared they would cause an excessive budgetary deficit.
The following year Jude Wanniski(°1936) published his book " How the World works " He stated that men learn the principles of economy during their childhood. They experience that each person defends his own interests and that to obtain an income you must produce goods for which there is a demand or render services to other persons. Wanniski is an opponent of the classical vision that during a recession the government must increase taxation in order to balance its budget. Such a rise discourages the producers and aggravates the crisis. Keynesian deficit spending works, because the citizens do not realise that in the end they will be taxed to pay the interest the state will award them.
When in 1980 Ronald Reagan (1911-2.004) was elected president he tried to apply the principles of supply .side economics . In 1981 he obtained a first set of fiscal reductions from the Congress and Senate. The following year other reductions were approved. They caused a huge deficit in the budget of the federation, but attracted much foreign capital as taxes were now lower than in Europe and Japan. Many European and Japanese capitalists invested money in American enterprises . Moreover, many foreigners bought American bonds. The great demand for dollars to pay for these purchases brought about an increase of the exchange rates of the dollar. A cumulative process started. The rise of the value of the dollar enhanced the purchase of American bonds and equity . In the end the dollar was strongly overvalued . The prices of American products in the world markets were no longer competitive with those of similar European and Asian products. American exports declined, and as foreign products priced in dollars became cheaper, imports increased. America had to import more foreign capital to pay for the deficit in its foreign trade Already in 1986 the United States were the most important debtor state in the world.
Many left wing economists and politicians considered this evolution as a prelude to a general collapse of capitalism . They were wrong .The booming of the American economy attracted more and more capital and encouraged the creation of new industries, especially in the sectors of informatics and biomechanics. America became again the leading nation in the field of modern technology.

In the mean time the failure of a socialist experiment in France and slow economic progress in the Soviet Union and most communist states, discredited the dreams of an alternative economic system. .In May 1981 the socialist François Mitterrand(1916-1996) became president of France. He intended to transform the French economy into a mixed system with an important public sector He appointed Pierre Mauroy(°1928) as prime minister of a government with the participation of French communists .This government nationalised 12 big industrial enterprises, 36 banks and 2 financial groups. The nationalised enterprises had to devise a program of activities in agreement with the government. Their" contrats de plan"were integrated in a great economic plan called " le plan intérimaire 1982-'83 ". Its purpose was to increase the competitiveness of the main French firms, which would obtain a greater part of the foreign markets . In order to acquire new technology certain foreign firms were bought by the nationalised industries .The government intended to reduce unemployment, which under the previous right-wing government had risen .By increasing French exports, expanding the domestic markets by government outlay and reducing the working time the government foresaw a decrease of unemployment by 400.000 units. However, during the years 1981-'83 French export did not rise as the world economy was in depression. The increase of the wage cost as a consequence of reducing working time with maintenance of the same wages, made French products more expensive . The income of the French working–class was increased and this caused more consumption of foreign goods and services. The balance of trade could not be kept in equilibrium. The balance of payments too deteriorated for many capitalists fled with their capital to other countries .The exchange rates of the national currency in international markets weakened. The government had to devalue its currency in order to reduce the outflow of foreign valuta. On October 4 1981 the French frank was devalued a first time with 3 per cent. On January 12 1982 followed a devaluation with 5.75 per cent and on March 21 1983 a third one with 2.5 per cent. Each time these devaluations took place together with a revaluation of the German mark. The French government expected that these devaluations would increase French exports. . However, they created distrust in the value of the French frank. More capital was exported and the balance of payments remained in the red.

In the end the new policy could not be maintained . In March 1983 the government of Mauroy was succeeded by a socialist government under the leadership of Laurent Fabius (°1946), in which the communists were not

represented. Laurent Fabius introduced "une politique de rigueur ". Government outlays were reduced, money creation by the banks was restricted and the increase of domestic demand stopped. All this brought about a reduction of imports and an improvement of the balance of payments. However, many adherents of a transfer to a socialist economy were disappointed .They realised that the " politique de rigueur " put an end to the increase of incomes of the working classes.

On March 16 1986 the socialist party lost the election. A right-wing government with Jacques Chirac (°1932) as premier took office . The laws of July 2 and August 6 1986 made possible the privatisation of most nationalised industries. The dream of a mixed economy was over.

During the eighties the members of the Warsaw Pact suffered from increasing economic difficulties . During the sixties and seventies they realised higher growth rates than the majority of the capitalist nations, but in the eighties their growth slowed down As the need for better products increased, the planning of economic activities became more difficult. Most planning agencies had the bad habit of making their plans on the basis of traditional technologies. They did not sufficiently take into account the new devices available.The central committee of the Soviet Union, which was the leading nation in the communist world , was composed of the elderly. They had experienced the unexpected German attack and feared that some day the powerful capitalist nations would try to destroy the communist world. Therefore they imposed the creation of powerful armies on all the members of the Warsaw Pact. An excessive number of their best technicians and a great part of their national resources were mobilised for military purposes. Moreover, important financial and material means were reserved for promoting the development of communist third world nations such as Vietnam, South Yemen, Ethiopia, Angola, Mozambique and Cuba. The organisation of many firms was inefficient. The communists did not tolerate unemployment Most enterprises had more workers than were necessary. A boss had no right to dismiss a member of his staff without offering him other work Often drunkards and other unproductive workers were paid the same low salaries as productive members. Such a system promoted general discouragement and indifference towards the results of economic plans. As a Polish worker declared :"We put on a semblance of working hard and the authorities try to make us believe they pay us well".As a consequence of this faulty way of management most consumption goods produced in the communist countries were of poor quality. In order to promote the sale of these products the state banks delivered extensive credits to the governments,

so that they could practice a liberal social policy. Pregnant women received good compensation for the loss of their salary during the period they were allowed to stay at home. Pensions were, compared with wages, rather high. Health care was free. The large outlays of the governments did not cause inflation because all prices were fixed by the government. There was an excess of purchasing power that was not used due to a lack of attractive consumption goods. When on March 11 1985 Mikhail Gorbachov (°1931) became head of the Soviet State in five industrial branches an experiment had been introduced in order to increase productivity. In these branches the managers had received more power to take decisions they judged favourable for efficiency.

Gorbachov extended this project to more industrial branches. Moreover, he stimulated journalists to demand information about the situation and the technological development in the diverse soviet firms. This was called "the glasnost". During the party congress number 27 he formulated the principals of "perestroika". All enterprises had to revise their production and marketing methods in such a way that they would cover their costs. Instead of delivering their products to the enterprises for distribution, they would be obliged to sell them . Gorbachov was convinced this measure would force managers to pay more attention to quality.

He considered an aggression from the Western nations as improbable. Therefore he wished to reduce the military outlays of the Soviet Union and its satellite states. In exchange for loans and subsidies from the Federal German Republic he agreed to withdraw the Russian troops from East-Germany. Moreover, he agreed that the Hungarians could open their Western frontier, so that persons from the Eastern-European countries could emigrate to the West. This brought about a massive emigration of the best workmen and their families to Western Europe and a collapse of all the East-European communist regimes. This collapse took most economists by surprise. They had overestimated the efficiency of the Soviet system and underestimated the need of its citizens for more freedom.

As the American author of Japanese origin Francis Fukuyama (°1952) explained in his book "The End of History and the Last Man"(1991) every human being needs to express his personal ideas and sentiments to his fellows. In communist countries it was not possible to criticise the working of the economic and cultural system without incurring the risk of being arrested and sent to prison or to a labour camp.

The communist states tried to increase the intellectual and cultural level of their citizens, but afterwards they refused to accept that these citizens

criticised the abuses in communist societies Such a contradiction could not last.
Fukuyama was convinced that the communist dream was therefore over. He believed that a return to such a system was impossible because it contradicts human nature.
The theory of Fukuyama about the political future of diverse nations has found a supplement in the book of Michael E. Porter (°1947)"The Competitive Advantage of Nations" (1990).Like Adam Smith he investigates why some nations succeed in attaining a higher economic growth than their neighbours He states that firms attain only a high degree of efficiency when they have to compete with others. In the communist nations such competition did not exist and therefore most enterprises stagnated in inefficiency.
In a globalised world, where many firms compete in the world markets, there are three ways to acquire a competitive advantage, namely :
-to reduce production costs beneath the normal level of competitors;
-to differentiate the aspects and qualities of the products in such a way that they better satisfy the needs of the potential customers;
-to focus on a limited number of products, in which the firm enjoys a competitive advantage.
Countries, where the firms are involved in fierce competition acquire a high level of prosperity. Their low production costs and the high quality of their products permit them to increase their exports . Afterwards when they have conquered some foreign markets, they can create in the countries of their foreign clients subsidiary firms and profit form the lower wages and omission of transport costs .
Porter's theories urged many governments to create institutions, which had to proceed against agreements and fusions ,which excluded or weakened competition.
In the European union the commissariat for the defence of competition extended its activities and imposed heavy fines on firms which by their commercial policies hindered the development of fair trade. Member states were pressed to eliminate monopolies of public enterprises for the production and supply of electricity, gas, drinking water, postal and telephone services.
Social-democratic parties, which traditionally were the main defendants of those public monopolies, have liberalised their doctrine. As a rule they agreed that private firms may compete with public enterprises. They now try to realise what they call " a social free market economy". However, it is doubtful if such a system can be maintained in a world where new big states

like China, India and Brazil are competing with the traditional industrial nations by means of low wages for millions of workmen .

6.Potential economic developments
Most economists agree that at this moment three different models of capitalism exist :

1. The Anglo-Saxon model :
It is based on the principle that everybody is responsible for creating the income necessary to support his family . Only when due to illness, invalidity or another serious reason which make it impossible for the main–breadwinner to work, must the state intervene.
This model of capitalism exists in the United States and in a less brutal degree in Great-Britain and some British ex-dominions. In these countries the level of taxation is lower than in European continental countries, but the services offered by the state to its citizens are more limited In the American health sector only the elderly and the very poor have free access to medical care. The great majority of the Americans have to underwrite costly private insurance policies. About one third of American children are not insured at all, because their parents can not pay the necessary premium.
In Great Britain all health care is free for everyone, but there are waiting lists for those who need surgery. As a consequence many take up private insurance and use private hospitals. There treatment is as a rule very expensive.
As to pensions in the United States everybody has to insure himself or must obtain private insurance from his employer. In Great Britain there are state pensions for everybody, but they are very low. Moreover, as the number of elderly people increases, the cost of state pensions is augmenting ..The Labour government which is confronted with a budgetary deficit and does not wish to raise the level of taxation, is planning to raise the age at which a citizen can obtain a pension from 60 to 65. Most members of the moneyed classes have an insurance, which guarantees them a reasonable pension at about sixty Almost all important firms have organised a pension fund, in which they invest a part of their benefits in order to guarantee reasonable pensions for the members of their staff. However, persons employed by such firms run the risk that the managers invest the money of he pension fund in their own firm in order to increase its profits. If in that case the firm fails the employees may lose their pension rights.

As far as education is concerned in the United States there are great differences in its quality in primary and secondary schools. Schools in wealthy neighbourhoods are as a rule well equipped with a lot of pedagogical material and have classes with a limited number of pupils. In poor neighbourhoods classes are often crowded and teachers have difficulties in maintaining discipline. Many American films have illustrated "the black-board jungles" in some poor industrial towns.

In Great–Britain too, primary and secondary public schools are often overcrowded, with classes of about thirty pupils . The Labour government intends to improve education by nominating more teachers and reducing administration.

As taxes are lower in the United States and in Great Britain than in most industrial nations multinational societies have located there a great number of their enterprises . The growth rate of their national income is higher than in continental Europe, where enterprises have to pay more taxes . Moreover, employees have to work more hours .In the United States the average working time is 40 per cent higher than in Europe. In the European Union Great Britain has regularly refused to approve proposals to reduce the maximum working-week to less than 48 hours.

2. The model of the European continent :

In most countries of the European continent the influence of Social and Christian democratic movements has been stronger than in Anglo-Saxon countries .

Therefore the social services offered to the citizens by the state or by organisations subsidised by the government are more important than in the Anglo-Saxon world Moreover, in the greater part of continental Europe councils with representatives of the employers and the trade unions for determining the wages and the other working conditions have been created... As a consequence the number of strikes is as a rule more limited than in the Anglo-Saxon countries, but wages are higher and working hours shorter.

In 2003 the average wage per hour in industry was higher in Denmark, Western Germany, Finland, Belgium, Sweden, Austria and France than in the United Kingdom and the United States. Profit rates are as a rule lower in continental Europe than in the United States and Great-Britain and this explains why economic growth is smaller and unemployment higher . Germany, which is considered as the most industrialised country of the European continent, had in 2.005 a growth rate of only 0.8 per cent. For 2.006 a small increase is anticipated, due to the growth of exports .The

growth rate would attain 1.2 per cent . In the whole Euro-zone the growth rates for 2005 and 2006 would be respectively 1.2 and 1.8 per cent. This is lower than growth rates in the United States and Great-Britain.

3. The model of the Scandinavian countries:

The Scandinavian states Denmark, Norway and Sweden have small populations, who have specialised in economic activities, which are related to the natural resources of these countries . Denmark, which has an important fishing fleet, produces fish oil, fish meal and tinned fish. As a traditional agricultural nation it has developed some specific biotechnical products and is an important producer of bio-vegetables . Its industry has specialised in machinery for the production of food commodities. Norway has an important petro- chemical industry and has a large income from its export of natural gas.

Sweden ,which has mines with high grade iron ore, has specialised in the metal industry.

The Scandinavian countries have in common that they were governed for long periods by Labour parties which practised policies in the interest of the common people. Taxation is very high .In 2.003 the fiscal income of the state amounted to 50.8 per cent of the national income in Sweden and 48.8 per cent in Denmark. In Norway taxes are lower because the government obtains a high income from its participation in the exploitation of petrol and gas The diverse social services are well developed and a great deal of the population is occupied by public organisations. .Norway has a mixed economy with public corporations active in the petrol and gas industry, the production and distribution of electricity, the railways and the postal services. In Sweden and Denmark the public sector is less important but private enterprises are subjected to strict regulation, which protects the employees against exploitation by capitalist societies. Wages are in most branches established by collective agreements between employers and trade unions. Unemployment is rather low, because Scandinavian governments have organised uniquely well-run employment services. In Sweden employers are legally bound to notify the employment services of all vacancies . People out of work have to keep in touch with their local state-run employment office. Together with the job-seeker, the employment office draws up an individual plan of action. A system of vocational training ensures that persons, who have lost their work in a stagnating industrial branch can find a job in an expanding industrial sector. This guarantees that the unemployed remain active and keep in touch with working life .Inequalities in salary remain

limited., due to the action of the trade-unions, which try to ensure that all employed persons obtain a reasonable income.

The globalisation of the world economy and the increase in the prices of energy have brought misgivings about the future of European capitalism.
Most European continental nations were mature economies in the sense described by Lamfallusy. Saving surpassed regularly investment . As a consequence European firms had to export a great part of their production. The balances of trade of these countries were positive and they could afford to export capital for investment in foreign enterprises.
The heavy increase of the price of oil and the appearance of new big competing nations such as China, India and Brazil in the world markets have an adverse influence on the balance of trade of Europe. The European nations have to pay more for oil and their export possibilities are reduced by the entry in the world markets of new competitors. Most European nations now have a deficit in their balance of trade. Moreover, their economic growth rates have declined to no more than 2 per cent a year, while the Chinese growth reaches 9 per cent a year. The American firm Goldman Sachs has calculated that at this growth rate in 2050 the gross national product of China will exceed that of the United States . India will occupy second place, and Europe fourth.
The European nations are unable to devise a common. economic policy to avoid their relative decline. In 2000 at a congress in Lisbon they decided that all member states had to increase their outlay for scientific and technological research to 3 per cent of their national income. By achieving this target Europe would become technologically the most advanced continent in the world.
However, this decision has not been implemented. It was but another political dream .
Confronted with big outlays for people on the dole and for the health care of an ageing population continental West European governments have neglected to realise the target, stipulated in the Lisbon Congress. The European community too has failed to increase its subsidies for scientific and technological research . In 2005 36.4 per cent of the outlay of the European Union was destined for agricultural subsidies against only 7.8 per cent for research, internal security and culture.
Tony Blair, who as prime minister of Great Britain, was president of the Council of European ministers during the second semester of 2005, proposed to reduce the EU's aid to the agricultural sector in order to reserve more

money for research and industrial development . This proposal met with stiff resistance from France and some other nations with an important agricultural sector. When in order to stop the production of sugar in the European Union the European commission decided to reduce the guaranteed prices it paid for beets and sugars, eleven member states (France, Belgium, Spain, Italy, Portugal, Finland, Latvia, Lithuania, Hungary, Slovakia and Greece) protested. This reduction is necessary to satisfy the claims of the sugar producing countries of Latin America, who complain that by exporting subsidised sugar the EU makes it impossible to sell sugar at reasonable prices. These countries refuse to lower their import duties for European products and services if the EU countries do not stop their dumping practices.
The president of the European commission José Manuel Barroso agrees with Blair that a revival of the Lisbon memorandum is necessary if the EU. wants to avoid stagnation.
However, he wishes to attain 3 per cent not by way of EU subsidies, but by means of lower taxes for firms, which organise a sufficient amount of scientific or technological research. From the 3 per cent 2 per cent would be realised in this way and only 1 per cent would be attributed as subsidies to public or private organisations.
This plan is in accordance with the advice of the Organization for Economic Co-operation and Development (O.E.C.D.), which insists that the nations of continental Europe must lower their social outlay in order to reduce heavy taxation on enterprises.

The new members of the EU practice as a rule lower taxation than the traditional members in order to attract more foreign investment . This has meant that all the member states follow a similar policy . They reduce taxation on industrial and commercial firms and increase indirect taxes. As indirect taxes are more painful for persons with a low income than for the rich , the result is a greater inequality in wealth.
Moreover, the diverse types of continental capitalism have to reduce their liberal social outlay in order to balance their budgets and lower their imports. At this moment most economists presume that the new German coalition government will lower taxes on enterprises, increase indirect taxation and freeze salaries .
The Scandinavian countries are in a better state to resist such an evolution to a more Anglo-Saxon type of capitalism. Till now the majority of their citizens accept high taxes because they value the good state social services. .

However, as people with a rather high income increases, opposition against the high taxes becomes stronger .Higher–income groups can look after themselves and therefore are more interested in lower taxes than in liberal social subsidies. In Denmark the Labour government was defeated in the parliamentary elections of November 2001 .In Sweden the Labour party is confronted with a regular falling of its membership and an increase of political apathy .In 1991 the party had 259.000 members in 2002 153.000.
It is not sure that Sweden's Social Democrats will be returned in power at the elections.
Anglo-Saxon types of capitalism seem more resistant to the challenge of Chinese competition than the European. This is due to a combination of circumstances, which permit American firms to realise higher profit rates than in most European countries. The fact that there is a continuing inflow of poor emigrants, who are ready to work long hours for a low salary increases the profits of many small and medium firms. There is also an important influx of foreigners ,who possess special skills and come to the States because they will be better paid and pay less taxes. Another important factor is the great number of patents at the disposal of important American firms. Great-Britain too has a high number of immigrants ,who are well integrated in the British economy. As immigrants have as a rule more children than the autochthonic families their presence reduces the problem of ageing .
These facts urge many right wing economists to warn governments of continental Europe that they must reduce their social outlay, lower taxation and allow more immigrants if they want to attain a sufficient economic growth rate and reduce the jobless. The present director of the International Monetary Fund, the Spaniard Rodrigo de Rato states in a recent interview with journalists of "Le Monde " that the European nations must revise their economic policy. They must stop protecting employees against prompt dismissal, abolish the practice of imposing minimum wages, and introduce more competition in the labour market. He is convinced that to slow down the increase of the cost of pensions it is necessary to raise the age at which employees retire. These measures favour the rich and would make the economic and social structure of continental Europe akin to that of the United States.
On the other hand left–wing economists propose an evolution towards a Scandinavian way of reorganising labour markets. John Monks (°1945), the General Secretary of the "European Trade Union Congress", describes in an article that in Sweden and Denmark a firm, which announces collective dismissals has to warn a public organisation, which will try to find new jobs

for the dismissed employees. They receive a dole, which is a fair percentage of their wage and are offered the possibility to retrain themselves for another job. Monks says that it is unjust and inefficient to let those, who lost their job, without any help to find a new workplace .He refers to what happened in Great Britain during the government of Mrs. Thatcher. The deregulation of the labour market resulted in an increase in poverty and inequality. Employees, who lost their jobs, were obliged to accept badly paid work and to leave their homes, because they could no longer pay the rent. Instead of accepting such downward labour flexibility, the government must organise a system that ensures the possibility of upward flexibility . Employees must have the opportunity to learn technologies which will guarantee them a higher income.Such upward flexibility may become reality if as the British Labour prime minister, Tony Blair proposes Europe becomes as a result of scientific and technological research a coalition of modern and dynamic nations.

This brings to the fore the question as to whether the private entrepreneurs and capitalists will be able and willing to organise such research and apply it for productive purposes .

The example of the United States suggests that this is possible . However, the majority of Europeans are not ready to give up their systems of social security in order to create a very dynamic society. That is the main reason why so many leaders of European nations are sceptical about the results of the proposals of Blair and Barroso concerning the revival of the Lisbon memorandum.

In France, where there is a tradition of industrial development planned and realised by public bodies, there are a lot of left-wing intellectuals, who prefer public initiatives instead of relying on the free market.. Patrick Artus, who is director of the center for economic studies of the saving banks , published in 2.005 a book " Le capitalisme est en train de s'autodétruire "(capitalism is destroying itself) in which he asserts that private firms are always trying to increase their profits in the short run and neglect the often nasty consequences of their actions in the long run. Therefore it is necessary to reorganise the saving and banking system and impose on the managers of private firms strict rules, which will guarantee a sound and sustainable growth of the national economy.The same year Jean Peyrelevade, ex head of the Suez group and the Crédit Lyonnais ,published his book "Le capitalisme total" (Global capitalism) in which he suggests limiting the power of shareholders in private corporations. The managers of these corporations should no longer be responsible to the shareholders but would have to follow

the instructions of the public planning bureau. To the shareholders would be guaranteed a reasonable dividend, so that they would have no interest in selling their shares . A take-over of a French corporation by foreign capitalists would be forbidden if it proved to be in contradiction with the industrial policy of the nation.
Such a proposal is contrary to the aims of the EU.. It must be considered as a reaction against the globalisation of the world economy. This globalisation limits more and more the possibilities of the nation states to plan their economic development.
Not only in Europe but also in the United States there exists much opposition against the present Anglo-Saxon type of capitalism. .
Some followers of Keynes, such as Robert Clower (°1926) and Axel Leijonhyfvud (°1933) stated already in the late sixties that a capitalist economy with a weak public sector is unstable. Keynes insisted that the entrepreneurs can not foresee the evolution of the economy .
Therefore they are inclined to follow the example of their competitors . They suppose that these are better informed. This causes excessive investment in various branches of the economy during booms and insufficient investment during depressions. When there exists an important public sector the fluctuations of investment are limited by the taxes on the profits of the various firms and the government outlays.
Optimists like the Dutch economist Willem H. Buiter(°1949) believe that in a free economy rapid technical progress guarantees that short recessions will always be followed by a quick recovery.
Other economists are less sure that a depression will always be avoided. During the boom many firms emit new equity in order to expand their operations. Due to speculative purchases of equity the notations of most stocks are excessive and a reaction becomes unavoidable . When it sets in everyone tries to sell before the notations are much lower.This brings about a crisis in the stock-exchange . It is no longer possible to find underwriters for new equity. Many firms, which foresaw great expansions can not realise their plans. They suffer big losses and some will fail and dismiss hundreds of employees. This reduces consumption outlay .Not only those who become unemployed buy less, but many other employees reduce their spending . They fear being dismissed. The producers of consumption goods are confronted with a reduced output, and will reduce their staff.
Such a dismal evolution occurred in the thirties and is still possible to day.
The higher demand for new goods and machinery enhances economic prosperity, but the increase of productivity due to the introduction of better

technology, reduces the demand for labour. Which of both consequences of the technological progress will predominate is uncertain. Much will depend on the financial resources of government. If in periods of recession it can expand its outlay for public investment and social services it will be able to stop the decline of gross demand for goods and services.

In Europe most governments are confronted with a combination of high outlay for social services and growing resistance of the citizens against heavy taxation The possibility to expand the outlay is limited. In the United States it is doubtful that a efficient system of insurance against .the nasty consequences of unemployment, illness, invalidity and old age will be organised . President Bill Clinton (°1946) tried in the years 1993-'94 to imitate the German system of social security and impose on all firms the obligation to pay contributions for insuring the families of the members of their staff against illness, invalidity and early death. In the election of November1994 the Republicans won a majority in both houses of Congress. As they were opponents of his huge program of health care reform, Clinton had to give up his plans. He declared "The era of big government is over". The resistance of the millions of small entrepreneurs against new outlay had proved to be too strong.

The Republican president George W. Bush (°1946) has at the beginning of his second term acknowledged that the actual system of American Social Security could not last.

In 1950 there were 16 persons who paid the payroll tax for one beneficiary of social security. . To-day there are 2.3 workers supporting every Social Security beneficiary Now the tax, which is subtracted from the wage is 6.2 % below an annual amount of $ 72.600 and the deduction for Medicare is 1.45 % of annual wages, with employers contributing matching amounts. This is not enough to guarantee a fair pension to every person older than 65 years and to pay the medical care of the many poor. Bush proposes to introduce a new system of personal Social security Investment Accounts. Every American would be encouraged to open such an account with a financial organisation. Workers would have the possibility to invest a part of their payroll tax in their personal account Later the public purse would pay them a lower pension, but they would obtain a supplement from their personal account. It is not evident, that this proposal can bring a solution to the problem of the lack of funds in the next years for the payment of pensions .The president believes that by investing the money of personal accounts in stocks and bonds the financial result will be higher than the actual return on the money paid to the social security administration. This

money is invested in federal securities with a low interest rate. There is also the problem as to what will happen if persons invest unwisely and lose a part of the money that they put in their personal account. Moreover, Bush plan does not solve the problem of the growing deficit of Medicare and Medicaid. Their outlays grow with 2.5 per cent more than the national income. They have to borrow huge sums. If nothing is done, in 2050 43 per cent of the gross national income will be necessary to cover the cost of their outlay and rent on their debts.

It is evident the whole American system of social security is in a mess and needs more money. However, the Republican party refuses to raise taxes in order to procure the necessary funds.
Their opponents the Democrats may win the elections of November 2007 and of November 2009, but it is doubtful if a president from that party can bring a solution.
The American economist Joseph E. Stigler (°1943),who was a counsellor of president Clinton, asserts in his book " The European Dream" (2004) that now the majority of Americans find life more agreeable in Europe than in America. Working people in America have longer working hours, less holidays and have to live with the constant fear to be dismissed if they become less productive or if the firm is reformed in order to increase its efficiency.
May be in the end American capitalism will evolve to a less brutal kind of capitalism or on the contrary the pressure of competition from the outside world may eliminate in Europe a deal of its more favourably social environment.

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LAUDATIO GUIDO VANDEN BERGHE

Willy Govaerts

Professor Guido Vanden Berghe (born at Bruges, Belgium in 1945) graduated from Ghent University where he obtained both the Master of Science degree and a Ph. D in Physics. He also obtained the teacher's license for teaching at secondary schools and later the habilitation for teaching at Universities, with a thesis on low energy nuclear physics.

Nuclear Physics was a hot topic in these days and Guido Vanden Berghe contributed to it from 1968 to 1971 as a researcher at the Interuniversity Institute for Nuclear Physics.

His scientific career took a new direction in 1971 when he became an assistant at Ghent University in the Institute (then called "Seminarie") of Mathematical Physics whose director was Professor C.C. Grosjean. Computer Science was a rapidly developing field in these days and was closely connected to numerical mathematics. Most present day developments in numerical mathematics can be traced back to these days though computer science developed in many other directions so that nowadays the link is less obvious.

In the Faculty of Sciences of Ghent University Guido Vanden Berghe had a decisive influence in directing research to computer science and numerical mathematics. As a consequence he became in 1989 the first chairman of the new department of Applied Mathematics and Computer Science, a position that he held to 1996 and later again from 2003 on.

Guido Vanden Berghe in a sense constructed the new department by bringing together several people from different institutes whose common interest was in computer science and applied mathematics. Without his enthusiasm and leadership the department would simply not exist.

In general, Guido Vanden Berghe has a great capacity for organization and for constructive collaboration with others. It is therefore not surprising that

he is active in many decision-making committees in the university as well as in external social, cultural and political organizations.

Since 1981 Guido Vanden Berghe taught various courses in the domains quantum mechanics, computer science, programming and numerical mathematics.

His extensive scientific work has led to more than one hundred and fifty publications in international scientific journals, usually on either physical or numerical topics and often on the crossroads of both fields, called computational physics. A large part of his work deals with numerical solution methods for ordinary differential equations, a research field in which he is an internationally recognized expert. Applications to physical problems are never far away.

Guido Vanden Berghe became a professor ("hoogleraar") in 1989 and a full professor ("gewoon hoogleraar") in 1996.

Since 1998 he became interested in the history of science, with a particular emphasis (not surprisingly) in applied mathematics. He is an excellent teacher both at university level and for a general audience. Since 1998 he gave more than fifty lectures on the history of science for social, cultural and scientific organizations in Flanders. In the same spirit he published several papers in Dutch for Flemish socio-cultural journals and in English for international journals. Still in the same spirit he co-organized several exhibitions, for example in the University Library in Ghent and in the Royal Library in Brussels.

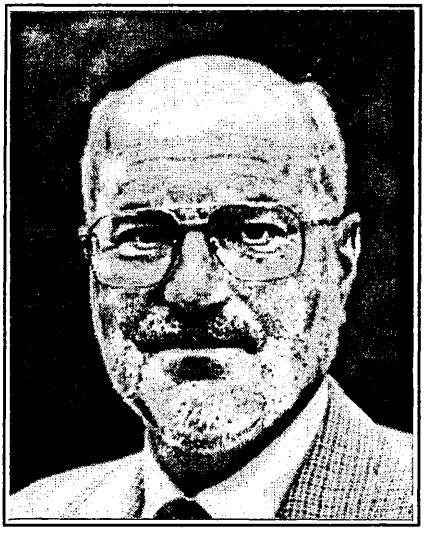
The name of Guido Vanden Berghe became widely known in the Dutch language region through the book that he published in 2003 in collaboration with Jozef Devreese of Antwerp University. The title "Wonder en is gheen wonder, De geniale wereld van Simon Stevin" refers to a saying of Simon Stevin (1548-1620) who is generally considered as the most important mathematician born in Flanders. It means that a miracle is not a miracle if you understand what is really going on.

Guido Vanden Berghe indeed was interested in particular in the life and lifetime of Simon Stevin, a man who nowadays might be called a mathematical engineer. This was also the time of two other famous Flemish

scientists, namely Vesalius (medicine) and Mercator (geography and map-making). It was also a politically important period when the Low Countries were separated into a southern and northern part. To many people this was (and to some it still is) a disaster. The separation has decisively influenced the life of Simon Stevin.

As a consequence of a long collaboration with K. Srinivasa Rao (India) Guido Vanden Berghe also published several papers on the life and work of the Indian mathematical prodigy child Ramanujan.

At first sight, Simon Stevin and Srinivasa Ramanujan do not have much in common except that they were both eminent mathematicians. Stevin was an applied mathematician with a clear interest in real applications while Ramanujan was equally clearly a pure mathematician. But they have in common that they both lived in politically difficult times and that they did their major work outside the country where they were born and spent their youth. Maybe this explains Guido's interest in scientific migration?



BRAIN DRAIN
NIL NOVE SUB SOLE
A HISTORICAL APPROACH

Guido Vanden Berghe

1. Introduction

"More than one in seven doctorates received by foreigners in the United States is awarded to Europeans. Of these Europeans, about 75 % stay behind. With generous research grants, state-of-the-art facilities, an international environment, and streamlined bureaucracy, America has a lot of going for it".[1] More and more the European decision makers and also the Belgian and Flemish politicians are aware of the problem. Europe has some of the most gifted scientific minds of the planet. After having completed a doctorate at their home university, young Europeans are often advised by their doctoral supervisor or laboratory on what direction to take for a post-doctorate. That often means North America. For many young researchers, the United States is a kind of initial immersion in the world of research, perhaps comparable to the trip to Rome that was the rigueur for the painters of the Renaissance. In Time [2] one can read that "around 400,000 E.U.- born science graduates live in the United States. Thousands more go to study and work each year. But the E.U. needs 700,000 more researchers by 2010. Can Europe bring its best and brightest back home? ". Governments in Europe started up programs to bring top researchers back to their native country with very attractive conditions. In this paper we like to show that such a kind of brain drain is not a phenomenon of the nowadays moment, but it has also been present in other periods of mankind history. Following examples will be discussed:

- The Arabic world in the period 786-900.
- The Renaissance time in the Low Countries.
- Brain drain out of the colonies: India as an example.
- Leo Backeland, a typical Flemish case.
- The escape out of Europe of Jewish scientists during the Nazi-regime.
- Operation paperclip after the Second World War.

2. The Arabic world in the period 786-900 [3]

Many Arabic researchers were associated with the remarkable House of Wisdom that was set up in Baghdad by the Caliph al-Ma'mun. It is worth looking at the events which led up to the founding of this important centre for learning.

Harun al-Rashid became the fifth Caliph of the Abbasid dynasty on 14 September 786, and ruled from his court in the capital city of Baghdad over the Islam Empire which stretched from the Mediterranean to India. He brought culture to his court and tried to establish the intellectual disciplines which at that time were not flourishing in the Arabic world. He encouraged scholarship and the first translations of Greek texts into Arabic, such as Euclid's *Elements* by al-Hajjaj, were made during al-Rashid's reign.

Al-Rashid had two sons, the eldest was al-Amin while the younger was al-Ma'mun. Harun died in 809 and there was an armed conflict between the brothers. Al-Ma'mun won the armed struggle and al-Amin was defeated and killed in 813. Following this, al-Ma'mun became Caliph and ruled the empire from Baghdad. He continued the patronage of learning started by his father and founded an academy called the *House of Wisdom* where Greek philosophical and scientific works were translated. He also built up a library of manuscripts, the first major library to be set up since that at Alexandria, collecting important works from Byzantium. In addition to the House of Wisdom, al-Ma'mun set up observatories in which Muslim astronomers could build on the knowledge acquired by earlier peoples.

This House of Wisdom became an attraction pole for Muslims and non-Muslims. Many mostly unknown researchers of high quality joined that school. They came from all places in the Arabic Empire. We like to stress the attention on two of them. Many others can be cited, but to our view Al-Kindi and Al-Khwarizmi were researchers of top level.

The Iranian philosopher, scientist, and ophthalmologist **Al-Kindi** (the Arabic name is Abu Yousuf Yaqub Ibn Ishaq al-Kindi) was born in Kufa – a town at 170 km in the south of Bagdad - in 800 BCE. His father was an official of Caliph al-Rashid. Al-Kindi was well known for his beautiful calligraphy. In fact, he was even employed as a calligrapher. In the Middle Ages, Al-Kindi was considered to be one of the greatest minds ever, in both Europe and the Arab countries. He was a master of many different areas of thought. He was an expert in music, philosophy, astronomy, medicine, geography, and mathematics, and spent many years in the House of Wisdom in Baghdad dedicated to his studies of these fields.

As a physician, Al-Kindi was the first pharmacologist to determine and apply a correct dosage for most of the drugs available at the time. As an advanced chemist, he was an opponent of alchemy; he debunked the myth that simple, base metals could be transformed into precious metals, such as gold or silver. In mathematics, he wrote a number of books dedicated to the number system, and contributed greatly to the foundation of modern arithmetic. Though Al-Khwarizmi (see hereafter) was the father of the Arabic system of numerals, Al-Kindi made many great developments in the field, as well.

Figure 1 : Al-Kindi

Figure 2: Al-Khwarizmi

Prolific to say the least, Al-Kindi authored at least two hundred and fifty books, contributing heavily to geometry (32 books), medicine and philosophy (22 books each), logic (9 books), and physics (12 books). His influence in the fields of physics, mathematics, medicine, philosophy and music were far-reaching and lasted for several centuries.

In "The Name of the Rose" [4] Al-Kindi is mentioned only in passing. William of Baskerville recognizes some books written in Arabic and translated into Latin. I feel that it was clever of Eco to have William comment on Al-Kindi, who, as mentioned earlier, was an ophthalmologist. Throughout the book, William is constantly talking about the new science that makes it pos-

sible for people to wear lenses on the face that magnify what one is looking at. This new discovery was, of course, eyeglasses. William loves the glasses so much that he is constantly putting them on so that everyone can see the new technology that he has, and they do not. Unfortunately, this leads to them being momentarily stolen (by a monk no less).

A second researcher of world importance is Abu Abdullah Mohammad Ibn Musa **al-Khawarizmi**, born at Khawarizm (Kheva), south of Aral Sea, now Uzbekistan around 780 . Very little is known about his early life, except for the fact that his parents had migrated to a place south of Baghdad. It is established that he flourished under Al- Ma'mun at Baghdad through 813-833 and probably died around 840 A.D.

Khawarizmi was a mathematician, astronomer and geographer. He was perhaps one of the greatest mathematicians who ever lived, as, in fact, he was the founder of several branches and basic concepts of mathematics. His work on algebra was outstanding, as he not only initiated the subject in a systematic form but he also developed it to the extent of giving analytical solutions of linear and quadratic equations, which established him as the founder of Algebra. The very name Algebra has been derived from his famous book *Al-Jabr wa-al-Muqabilah*. His arithmetic synthesised Greek and Hindu knowledge and also contained his own contribution of fundamental importance to mathematics and science. Thus, he explained the use of zero, a numeral of fundamental importance developed by the Arabs. Similarly, he developed the decimal system so that the overall system of numerals, 'algorithm' or 'algorizm' is named after him. In addition to introducing the Indian system of numerals (now generally known as Arabic numerals), he developed at length several arithmetical procedures, including operations on fractions. It was through his work that the system of numerals was first introduced to Arabs and later to Europe, through its translations in European languages. He developed in detail trigonometric tables containing the sine functions. He is also reported to have collaborated in the degree measurements ordered by Mamun al-Rashid which were aimed at measuring of volume and circumference of the earth.

The development of astronomical tables by him was a significant contribution to the science of astronomy, on which he also wrote a book. The contribution of Khawarizmi to geography is also outstanding: he revised Ptolemy's views on geography, but also corrected them in detail as well as his map of the world. His other contributions include original work related to clocks, sun-dials and astrolabes.

Several of his books were translated into Latin in the early 12th century. In

fact, his book on arithmetic, *Kitab al-Jam'a wal- Tafreeq bil Hisab al-Hindi*, was lost in Arabic but survived in a Latin translation. His book on algebra, *Al-Maqala fi Hisab-al Jabr wa-al- Muqabilah*, was also translated into Latin in the 12th century, and it was this translation which introduced this new science to the West "completely unknown till then". He astronomical tables were also translated into European languages and, later, into Chinese. His geography captioned *Kitab Surat-al-Ard*, together with its maps, was also translated. In addition, he wrote a book on the Jewish calendar *Istikhraj Tarikh al-Yahud*, and two books on the astrolabe.

The influence of Khawarizmi on the growth of science, in general, and mathematics, astronomy and geography in particular, is well established in history. Several of his books were readily translated into a number of other languages, and, in fact, constituted the university text-books till the 16th century. His approach was systematic and logical, and not only did he bring together the then prevailing knowledge on various branches of science, particularly mathematics, but also enriched it through his original contribution. No doubt he has been held in high repute throughout the centuries since then. The House of Wisdom to which many researchers, Muslims, but also Jews, Christians and some people with other faiths have been attracted was the birthplace of many new ideas. Recent research paints a new picture of debt that we owe to the Arabic/Islamic mathematics, studied by these people and their successors. Many ideas which were previously thought to have been brilliant new conceptions due to European mathematicians of the sixteenth, seventeenth and eighteenth centuries find their roots in this particular House.

3. The Renaissance time in the Low Countries (1500-1648) [5]

In the beginning of the period we like to discuss here, Emperor Charles V (Charles Quint) was ruling over a large part of Europe, including the Low Countries at the North-Sea

He was emperor of Germany - including Austria, Hungary, Parts of the Balkan, and Italy - as the successor of his grandfather from father's side. He was the owner of the Low-Countries (approximately the Benelux); he was the king of Spain and all the countries (colonies) in America and Asia as the successor of his grandfather from mother's side. In 1555 Charles abdicated from the throne. The Low Countries were attached to Spain and the ruler was Charles' son, Philippe II. Later on in 1598 Philippe's daughter Isabella and her husband Albrecht were ruling the country. It was a time of civil wars in the Low Countries. The people following the protestant religion, especially

the Calvinist ones, started a movement of opposition against Philippe II; this scattered over all provinces of the country and soon imparted a revolutionary character. The Low Countries broke into two parts, the Northern part, the Republic of the Netherlands under the leadership of Guillaume or William the Silent, Prince of Orange and later under his sons, Maurice and Frederik Hendrik. In this Northern part the Calvinist religion was state religion. The Southern part became the so-called Spanish Netherlands and remains Catholic.

Figure 3: Desiderius Erasmus

Figure 4 : Gemma Frisius

In this period of one hundred and fifty years one observes two streams of movements of researchers in the Low Countries. Before the religious civil wars the University of Leuven, founded in 1425, was considered as the Mecca of wisdom in this part of Europe. Its academic fame attracted numerous scholars who made valuable contributions to European culture. Allow us to enumerate a few renowned names born in the Northern part of the Low Countries and moved to the South for their studies and scientific activities. The humanist, Desiderius **Erasmus**, lectured in Leuven. Desiderius Erasmus, was born at Rotterdam, apparently on October 28, 1466, as the illegitimate son of a physician's daughter by a man who afterwards turned monk. He studied in many places in Europe, but in 1517 he founded in Leuven the Collegium Trilingue in 1517 for the study of Hebrew, Latin and Greek - the first of its kind. The tutor of the young emperor Charles V, Adriaan Cardinal Florensz of Utrecht, was a professor in Leuven at that College before being elected in 1522 as Pope Adrianus VI.

A typical example of a native of the North who has spent his life time in Leuven is **Gemma Frisius** (1508-1555) [6]. Regnier Gemma Frisius is born in Friesland, a coastal province in northern Netherlands, which explains why he gave himself the name of Frisius. He was born Regnier Gemma and only adopted the name Frisius when he later became a scholar. Like many scholars from his country, he adopted a Latin version of his name. So Regnier Gemma became Gemma Frisius. His parents were very poor people and both died when he was still a young child. Left an orphan and a cripple, he was brought up by his stepmother who on a special feast day, when Gemma was six years old, took him to the shrine of St Boniface in Dokkum. Certainly after this his legs which could not support his weight became stronger and his family believed that he had been cured by a miracle. Certainly given the difficult start he had in life it was indeed a miracle that he was able to achieve so much but, however, he remained a frail person all his life.

Gemma attended school in Groningen then, in 1526, he entered the University of Leuven. Of course his stepmother did not have the means to support him financially through university but he was given a poor student's place in Lily College. He studied for a medical degree but remained at Leuven to study mathematics and astronomy. He went on to become the leading theoretical mathematician in the Low Countries and also to become professor of medicine and mathematics at the University of Leuven. He was also a practicing physician in the same town. Gemma Frisius applied his mathematical expertise to geography, astronomy and map making. In Leuven he cooperated with the engraver and goldsmith Gaspard Van der Heyden (also known as Gaspar à Myrica) in the construction of maps, globes and astronomical instruments. From 1534 Gemma Frisius began to teach his student Gerardus Mercator. Together with Mercator and Van der Heyden, Frisius constructed a terrestrial globe in 1536 and a celestial globe in the following year. Both globes had been protected by copyright by Charles V with Imperial charters. Gemma Frisius made many astronomical observations. In particular he recorded comets in July 1533, January 1538 and 30 April 1539.

In 1533 Frisius published *Libellus de locurum* which described the theory of trigonometric surveying and in particular contains the first proposal to use triangulation as a method of accurately locating places. This provided an accurate means of surveying using relatively few observations. Positions of places were fixed as the point of intersection of two lines and, as Frisius pointed out, only one accurate measurement of actual distance was required to fix the scale. Not only did Frisius propose an efficient theoretical method for surveying which was needed to produce accurate maps, but he also pro-

duced the instruments with which to undertake the surveys and he published accurate maps using the data gathered from such surveys. He can be seen as the father of the modern cartography.

Gerardus Mercator (1512-1594) is a typical example of someone attracted by the scientific knowledge present at Leuven University, but he is also one of the first scientists leaving the Low Countries due to religious reasons [7]. Gerard Mercator's parents were Hubert and Emerentia Kremer. Hubert Kremer worked the land and also was a cobbler, which is a shoemaker. Hubert and Emerentia were people of lowly status but Hubert had a brother Gisbert who had been educated at Leuven University and was a priest in Rupelmonde. It was in the hospice of St Johann in Rupelmonde, where Gisbert was a priest, that Gerard was born. He was the seventh child of Hubert and Emerentia who, a few weeks after the birth, returned to their home town of Gangelt (Germany).

For the first five years of his life Gerard and his parents lived in difficult conditions in Gangelt. The family income was insufficient to provide for more than the basic needs of life and most of their diet consisted of bread for they could afford little else. The family journeyed from Gangelt to Rupelmonde to begin a new life. Gerard began attending school in Rupelmonde shortly after the family came to live there. At school he studied Latin, religion and arithmetic. By the time he was seven years old he was able to speak and to read Latin fluently. Hubert died in 1526 or 1527. His brother Gisbert became Gerard's guardian.

Gisbert wanted the very best education possible for Gerard so in about 1527 he sent him to be educated with the Brethren of the Common Life in 's Hertogenbosch in the Netherlands. While Gerard was there his mother died and he chose a new name for himself. His name 'Kremer' means 'merchant' in German and he was sometimes known as 'Cremer' which is the Dutch equivalent. As a new name he chose Mercator, the Latin for 'merchant' and gave himself the full name of Gerardus Mercator de Rupelmonde.

On 29 August 1530 Mercator matriculated at the University of Leuven, taking the course in the humanities and philosophy. He studied at the Castle, one of four teaching houses of the university which offered two year Arts degrees based almost entirely on the teachings of Aristotle. He graduated from Leuven with a Master's Degree in 1532 and chose not to proceed to a higher degree. Already he felt that he wanted to challenge the views of Aristotle, yet this was as heretical at Leuven at that time as challenging the views of the Catholic Church.

Figure 5: Young Mercator

Figure 6: Gerardus Mercator

This almost certainly explains why he chose to leave the university rather than study for a higher degree, since he had already decided that he did not want to become a philosopher. He travelled to a number of places while going through this personal crisis including Antwerp and Mechelen. His travels did little for his religious worries but gave him a deep interest in geography which he saw at the subject which could best explain the structure of the world which God created.

Mercator returned to Leuven in 1534 where he now studied mathematics under Gemma Frisius. However, not having any background in the subject, Mercator soon found that the mathematics courses beyond him. Realising that Mercator wanted to learn mathematics to apply it to cosmography, Gemma Frisius gave him advice on the best route into learning the mathematics he needed to know, giving him books to study at home. Once put on the right path by Gemma Frisius, Mercator quickly progressed in understanding and enjoyment of mathematics.

In September 1536 Mercator married Barbara Schelleken and they had six children, three daughters and three sons. Mercator was arrested in February 1544 and charged with heresy. This was partly due to his Protestant beliefs, partly due to the fact that he travelled so widely to acquire data for his maps that suspicions were aroused. He spent seven months in prison in Rupel-

monde castle. Others that were arrested at the same time admitted that they did not believe that the body of Christ was physically present in the communion host and they did not believe in purgatory. They were burned at the stake or buried alive. Nothing was found to connect Mercator with the others 'heretics' even after they had been tortured. Mercator's house was searched and his belongings confiscated but nothing incriminating was found to show that he was anything other than a good Roman Catholic. He was released from prison in September 1544, mainly due to strong support from the University of Leuven. In 1552 Mercator moved to Duisburg where he opened a cartographic workshop. The fact that a new university was planned for the town meant that he anticipated a ready demand for maps, books, globes and mathematical instruments. In Duisburg Mercator completed his project to produce a new map of Europe by October 1554. It was a large map, 1.6 metres by 1.3 metres. This re-established Mercator as the leading European map maker and, as well as praise for its scholarly value, the map had considerable commercial value.

Mercator was appointed Court Cosmographer to Duke Wilhelm of Cleve, also in 1564. During this period he began to perfect a new map projection for which he is best remembered. The 'Mercator projection' that bears his name was first used by him in 1569 for a wall map of the world on 18 separate sheets. He died in Duisburg in 1594. Mercator is a typical example of the expulsion of intellectuals out of the South part of the Low Countries in that period of religious wars. Other will follow and will give a start to the development of the Golden Era in the Republic of the Netherlands.

The University of Leiden [8] was founded in 1575 by Prince William of Orange, leader of the Dutch revolt. The presence within half a century of the date of its foundation of scholars moved from the South to the North in the Low Countries, such as Justus Lipsius, Franciscus Gomarus, Franciscus Heinsius, Simon Stevin, Carolus Clusius and many others, at once raised Leiden University to the highest European fame.

Gomarus was born in Bruges on 30 January 1563 and died in Groningen on 11 January 1641. He was a Reformed theologian; in 1587 he was a minister in Frankfurt, and in 1594 he became a professor in Leiden. In 1604 he initiated a theological dispute about Predestination with his colleague Arminius. In 1609 he resigned his chair in Leiden and became a preacher and lecturer in Middelburg. In 1615 he was appointed professor in Saumur, and in 1618 in Groningen. He contributed to the *Statenvertaling* (States Translation) of the Bible.

Bonaventura Vulcanius was born in Bruges, and died in Leiden in 1614 at the age of 77. He was Leiden's professor of Greek; he had previously been secretary to Marnix van St Aldegonde. Vulcanius left a few writings containing comments against the Catholic Church. During his time in Leiden a handwritten work by Cornelius Aurelius (1460-1531) came into his possession. This Dutch historian was a Latin poet and a friend of Erasmus. Vulcanius adapted the text, crossed out those parts of the original manuscript he considered irrelevant, and sent it off to the printer.

The humanist **Franciscus Nansius** was also a native of Bruges. He moved to Leiden and later taught at the Latin school in Dordrecht. He had a large private library. When his books were sold after his death the University of Leiden bought a number of ninth-century manuscripts, copies of classical authors of the fourth and fifth centuries, the originals of which had long vanished.

Justus Lipsius (the Latinized version of Joest Lips) was born in Overyssche, a village near Brussels and Leuven, in 1547. He studied first with the Jesuits in Cologne and later at the Catholic University of Leuven. After completing his education he visited Rome, in his new position as secretary to Cardinal Granvelle, staying for two years in order to study the ancient monuments and explore the unsurpassed libraries of classical literature. In 1572 Lipsius's property in Belgium was taken by Spanish troops during the civil war while he was away on a trip to Vienna. Without property, Lipsius applied for a position at the Lutheran University of Jena. This was the first of a number of institutional moves that required Lipsius to change his publicly professed faith. His new colleagues at Jena remained sceptical of this radical transformation and Lipsius was eventually forced to leave Jena after only two years in favour of Cologne. While at Cologne he prepared notes on Tacitus that he used in his critical edition of 1574. In 1576 Lispius returned to Catholic Leuven. However after his property was looted by soldiers a second time he fled again in 1579, this time to the Calvinist University of Leiden. He remained at Leiden for thirteen years and it is to this period that his two most famous books – *De Constantia Libri Duo* (1584) and *Politicorum sive Civilis Doctrinae Libri Sex* (1589) – belong. However, Lipsius was by upbringing a Catholic and eventually he sought to return to Leuven, via a brief period in Liège. In 1592 Lipsius accepted the Chair of Latin History and Literature at Leuven. To this final period belong his editorial work on Seneca and his two detailed studies of Stoicism, the *Manuductio ad Stoicam Philosophiam* and *Physiologia Stoicorum*. The two studies were published first in 1604 and the edition of Seneca in 1605. Lipsius died in Leuven in 1606.

Simon Stevin is born in Bruges in 1548 [9]. Simon Stevin's father was Anthuenis (Anton) Stevin who, it is believed, was a cadet son of a mayor of Veurne. His mother was Cathelijne van der Poort who was the daughter of a burgher family of Ypres. Anthuenis and Cathelijne were not married but Simon's mother Cathelijne later married a man who was involved in selling carpets and in the silk trade.

Figure 7: Oil portrait of Stevin


DE

THIENDE

Leerende door ongehoorde lichticheyt allen rekeningen onder den Menschen noodich vallende, afveerdighen door heele ghemlen sonder ghebrokenen.

Beschreven door SIMON STEVIN *van Brugghe.*

TOT LEYDEN,
By Christoffel Plantijn.
M. D. LXXXV.

Figure 8: The front page of the Thiende

By marriage Cathelijne joined a family who were Calvinists. Nothing is known of Simon's early years or of his education although one assumes he was brought up in the Calvinist tradition. Stevin became a bookkeeper and cashier with a firm in Antwerp. Then in 1577 he took a job as a clerk in the tax office at Bruges. After this he moved to Leiden in 1581 where he first attended the Latin school, then he entered the University of Leiden in 1583 (at the age of 35). While Stevin was at the University of Leiden he met Maurits (Maurice), the Count of Nassau, who was William of Orange's second son. The two became close friends and Stevin became mathematics tutor to the Prince as well as a close advisor. Maurits understood the importance of military strategy, tactics, and engineering in military success. In 1600 he asked Stevin to set up an engineering school within the University of Leiden. It was a good political move to insist that the courses were taught there in the

Dutch language. The author of 13 books, Simon Stevin made significant contributions to trigonometry, mechanics, architecture, musical theory, geography, fortification, and navigation. In 1585 he published *De Thiende*, a twenty-nine page booklet in which he presented an elementary and thorough account of decimal fractions. Although he did not invent decimals (they had been used by the Arabs and the Chinese long before Stevin's time) he did introduce their use in mathematics in Europe. Stevin states that the universal introduction of decimal coinage, measures and weights would only be a matter of time. Robert Norton published an English translation of *De Thiende* in London in 1608. It was titled *Disme, The Arts of Tenths or Decimal Arithmetike* and it was this translation which inspired Thomas Jefferson to propose a decimal currency for the United States (note that one tenth of a dollar is still called a dime). This book features in the famous Philadelphia list *Printing and the Mind of Man*, which highlights books that have had an impact on the evolution of Western Civilisation. Inspired by Archimedes, Stevin wrote important works on mechanics. Mainly dealing with statics, his treatment appears in his book *De Beghinselen der Weegconst* published in 1586. It is famous for containing the theorem of the triangle of forces which gave impetus to statics. In the same year his treatise *De Beghinselen des Waterwichts* on hydrostatics contained notable improvements to the work of Archimedes on this topic. Many consider that he founded the science of hydrostatics with this work by showing that the pressure exerted by a liquid upon a given surface depends on the height of the liquid and the area of the surface. Stevin died in Den Haag in 1620.

Charles de L'Ecluse **or Carolus Clusius** (Arras, February, 1525 - Leiden April, 1609) was a Flemish doctor and pioneering botanist, perhaps the most influential of all 16th century scientific horticulturists. He established the first formal botanical garden of Europe at Leyden, the *Hortus Academicus*, in 1587; he was appointed professor at the University of Leiden in 1594. His detailed planting lists have made it possible to recreate his garden near where it originally lay.

In the history of gardening he is remembered not only for his scholarship but also for his observations on tulips "breaking causing the many different flamed and feathered varieties", which led to the speculative tulipomania of the 1630s. Clusius laid the foundations of Dutch tulip breeding and the bulb industry today. Clusius, as he was known to his contemporaries, published two major original works: his *Rariorum plantarum historia* (1601) is the first

record for approximately 100 new species and his *Exoticorum libri decem* (1605) is an important work on exotic flora, both still often consulted. He also published other works, including one of the earliest known books on Spanish flora, *Rariorum aliquot stirpium per Hispanias observatarum historia*. Clusius translated several contemporary works in natural science.

Figure 9: Carolus Clusius

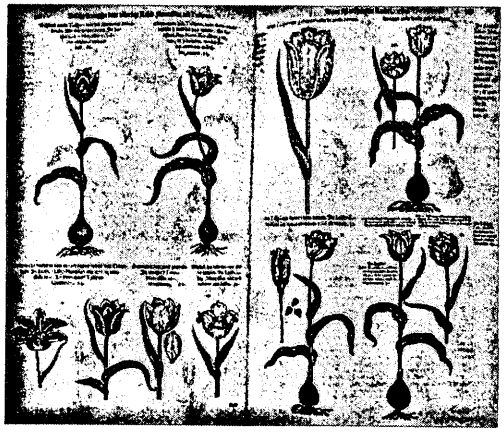


Figure 10: Page with drawings of tulips in one of the works of Clusius.

We have mentioned the names and short bibliographies of some of the scientists, who have left the South in order to help the North to build up a new society. The brain drain from the South to the North in the Low Countries was a disaster for the South, which left as a poor country with only a minority of intellectuals.

4. Brain drain out of the colonies: India as an example

End of the ninetieth, begin of the twentieth century the European countries had a lot of colonies in Africa and Asia. Especially Great Britain has a well developed colonial system in India, where a net of primary and secondary school, as well as universities were established. The best students were drained to the well-known English universities to do specialised research and to obtain a PhD. Many of them did not return to their home land but accepted

a teaching and research position in the Western world. As an example we discuss here the lives and work of the mathematician Srinivasa Ramanujan and the astronomer Subramanyan Chandrasekhar.

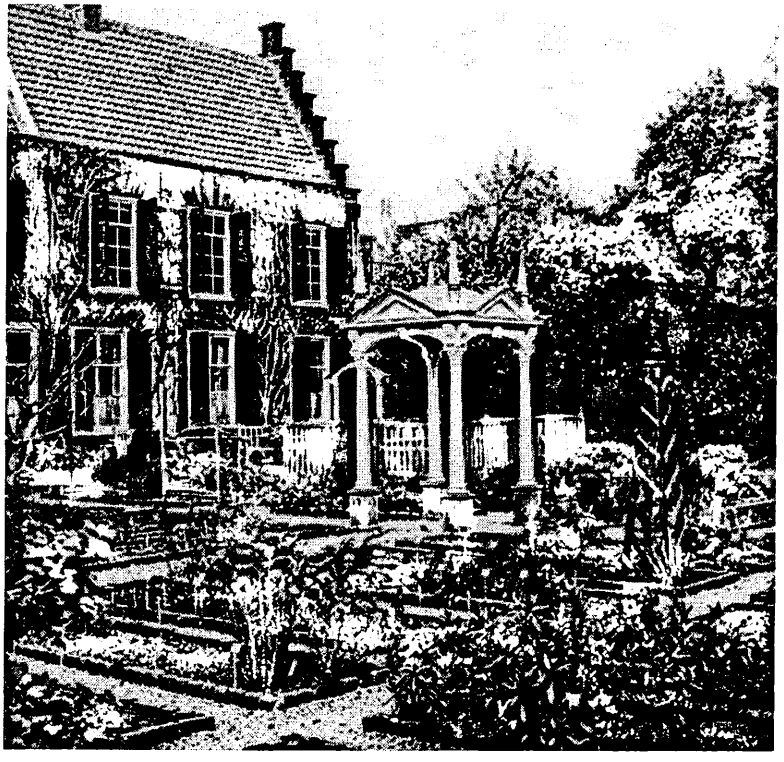


Figure 11: The re-constructed Clusius garden in Leiden

Srinivasa Ramanujan [10] (1887-1920) was one of India's greatest mathematical geniuses. He made substantial contributions to the analytical theory of numbers and worked on elliptic functions, continued fractions, and infinite series.

Ramanujan was born in his grandmother's house in Erode, a small village

about 400 km southwest of Madras. When Ramanujan was a year old his mother took him to the town of Kumbakonam, about 160 km nearer Madras. His father worked in Kumbakonam as a clerk in a cloth merchant's shop.

When he was nearly five years old, Ramanujan entered the primary school in Kumbakonam although he would attend several different primary schools before entering the Town High School in Kumbakonam in January 1898. At the Town High School, Ramanujan was to do well in all his school subjects and showed himself an able all round scholar. In 1900 he began to work on his own on mathematics summing geometric and arithmetic series.

Ramanujan was shown how to solve cubic equations in 1902 and he went on to find his own method to solve the quartic. The following year, not knowing that the quintic could not be solved by radicals, he tried (and of course failed) to solve the quintic.

It was in the Town High School that Ramanujan came across a mathematics book by G. S. Carr called *Synopsis of elementary results in pure mathematics*. This book, with its very concise style, allowed Ramanujan to teach himself mathematics, but the style of the book was to have a rather unfortunate effect on the way Ramanujan was written later down mathematics since it provided the only model that he had of written mathematical arguments. The book contained theorems, formulae and short proofs. It also contained an index to papers on pure mathematics which had been published in the European Journals of Learned Societies during the first half of the 19th century. The book, published in 1856, was of course well out of date by the time Ramanujan used it.

Ramanujan, on the strength of his good school work, was given a scholarship to the Government College in Kumbakonam which he entered in 1904. However the following year his scholarship was not renewed because Ramanujan devoted more and more of his time to mathematics and neglected his other subjects. Without money he was soon in difficulties and, without telling his parents, he ran away to the town of Vizagapatnam about 650 km north of Madras. He continued his mathematical work, however, and at this time he worked on hypergeometric series and investigated relations between integrals and series. He was to discover later that he had been studying elliptic functions.

In 1906 Ramanujan went to Madras where he entered Pachaiyappa's College. His aim was to pass the First Arts examination which would allow him to be admitted to the University of Madras. He attended lectures at Pachaiyappa's College but became ill after three months study. He took the First Arts ex-

amination after having left the course. He passed in mathematics but failed all his other subjects and therefore failed the examination. This meant that he could not enter the University of Madras. In the following years he worked on mathematics developing his own ideas without any help and without any real idea of the then current research topics other than that provided by Carr's book.

Continuing his mathematical work Ramanujan studied continued fractions and divergent series in 1908. At this stage he became seriously ill again and underwent an operation in April 1909 after which he took him some considerable time to recover. He married on 14 July 1909 when his mother arranged for him to marry a ten year old girl S. Janaki Ammal. Ramanujan did not live with his wife, however, until she was twelve years old.

Ramanujan continued to develop his mathematical ideas and began to pose problems and solve problems in the *Journal of the Indian Mathematical Society*. He developed relations between elliptic modular equations in 1910. After publication of a brilliant research paper on Bernoulli numbers in 1911 in the *Journal of the Indian Mathematical Society* he gained recognition for his work. Despite his lack of a university education, he was becoming well known in the Madras area as a mathematical genius.

In 1911 Ramanujan approached the founder of the Indian Mathematical Society for advice on a job. After this he was appointed to his first job, a temporary post in the Accountant General's Office in Madras. In 1912 Ramanujan applied for the post of clerk in the accounts section of the Madras Port Trust. Ramanujan was appointed to the post of clerk and began his duties on 1 march 1912. Ramanujan was quite lucky to have a number of people working round him with training in mathematics. In January 1913 Ramanujan wrote to G. H. Hardy, professor in Cambridge, having seen a copy of his 1910 book *Orders of infinity*. In Ramanujan's letter to Hardy he introduced himself and his work:

I have had no university education but I have undergone the ordinary school course. After leaving school I have been employing the spare time at my disposal to work at mathematics. I have not trodden through the conventional regular course which is followed in a university course, but I am striking out a new path for myself. I have made a special investigation of divergent series in general and the results I get are termed by the local mathematicians as 'startling'.

Hardy, together with his colleague Littlewood, studied the long list of unproved theorems which Ramanujan enclosed with his letter. On 8 February he replied to Ramanujan, the letter beginning:

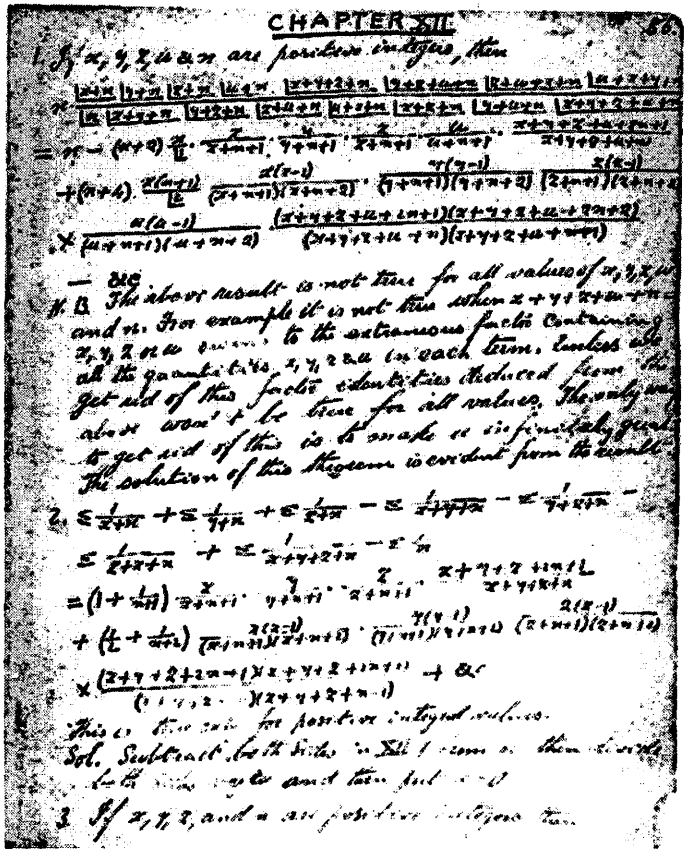


Figure 12: An example of one of the pages of the Notebooks

I was exceedingly interested by your letter and by the theorems which you state. You will however understand that, before I can judge properly of the value of what you have done, it is essential that I should see proofs of some of your assertions. Your results seem to me to fall into roughly three classes:
(1) there are a number of results that are already known, or easily deducible from known theorems;
(2) *there are results which, so far as I know, are new and interesting, but interesting rather from their curiosity and apparent difficulty than their im-*

portance;
(3) *there are results which appear to be new and important...*
Ramanujan was delighted with Hardy's reply and when he wrote again he said:
I have found a friend in you who views my labours sympathetically. ... I am already a half starving man. To preserve my brains I want food and this is my first consideration. Any sympathetic letter from you will be helpful to me here to get a scholarship either from the university or from the government.
Indeed the University of Madras did give Ramanujan a scholarship in May 1913 for two years and, in 1914, Hardy brought Ramanujan to Trinity College, Cambridge, to begin an extraordinary collaboration. Setting this up was not an easy matter. Ramanujan was an orthodox Brahmin and so was a strict vegetarian. His religion should have prevented him from travelling but this difficulty was overcome, partly by the work of E. H. Neville who was a colleague of Hardy's at Trinity College and who met with Ramanujan while lecturing in India.
Ramanujan sailed from India on 17 March 1914. It was a calm voyage except for three days on which Ramanujan was seasick. He arrived in London on 14 April 1914 and was met by Neville. After four days in London they went to Cambridge and Ramanujan spent a couple of weeks in Neville's home before moving into rooms in Trinity College on 30th April. Right from the beginning, however, he had problems with his diet. The outbreak of World War I made obtaining special items of food harder and it was not long before Ramanujan had health problems.
Right from the start Ramanujan's collaboration with Hardy led to important results. The war soon took Littlewood away on war duty but Hardy remained in Cambridge to work with Ramanujan. Even in his first winter in England, Ramanujan was ill and he wrote in March 1915 that he had been ill due to the winter weather and had not been able to publish anything for five months. What he did publish was the work he did in England, the decision having been made that the results he had obtained while in India, many of which he had communicated to Hardy in his letters, would not be published until the war had ended.

Figure 13: The photograph on the passport of Ramanujan as given on the cover of a popular book.

On 16 March 1916 Ramanujan graduated from Cambridge with a Bachelor of Science by Research (the degree was called a Ph.D. from 1920). He had been allowed to enrol in June 1914 despite not having the proper qualifications. Ramanujan's dissertation was on *Highly composite numbers* and consisted of seven of his papers published in England.

Ramanujan fell seriously ill in 1917 and his doctors feared that he would die. He did improve a little by September but spent most of his time in various nursing homes.

On 18 February 1918 Ramanujan was elected a fellow of the Cambridge Philosophical Society and then three days later, the greatest honour that he would receive: his name appeared on the list for election as a fellow of the

Royal Society of London. His election as a fellow of the Royal Society was confirmed on 2 May 1918, and then on 10 October 1918 he was elected a Fellow of Trinity College Cambridge, the fellowship to run for six years. The honours which were bestowed on Ramanujan seemed to help his health improve a little and he renewed his efforts at producing mathematics. By the end of November 1918 Ramanujan's health had greatly improved. Ramanujan sailed to India on 27 February 1919 arriving on 13 March. However his health was very poor and, despite medical treatment, he died there the following year.

Srinivasa Ramanujan left behind Notebooks [11] in which he noted more than 3000 results without proofs, during the period 1904--1912, when he was searching for a benefactor after having failed to pass the First Degree in Arts examinations of the University of Madras (in 1907). These Notebooks were with Ramanujan during his five year sojourn at Trinity College, Cambridge but Ramanujan was so busy with his research work and publications -- twenty-one papers, five in collaboration with Hardy, besides five short notes in Records of proceedings of meetings of the London Mathematical Society, six more in the Journal of the Indian Mathematical Society and several Questions (about twenty-five) to the Journal of the Indian Mathematical Society -- that he did not have the time to publish the contents of his Notebooks.

A few years after Ramanujan's death, Hardy spent three to four months on the two Chapters on hypergeometric series in the Notebook 1 of Ramanujan, and in the introduction to the paper he published [12] on this topic, he wrote:

A systematic verification of the results would be a very heavy undertaking.

Though he discontinued the study of the Notebooks of Ramanujan, after this work, he wrote to the authorities of the University of Madras suggesting that these Notebooks should be edited. In 1931, the University of Madras requested G.N. Watson to edit the Notebooks in a suitable form for publication. Watson undertook the task of editing with B.M. Wilson but the untimely death of Wilson in 1935 put an end to the joint effort. Eventually, in 1957, a facsimile edition of the Notebooks was published by the Tata Institute of Fundamental Research (India). A flurry of research papers followed the publication of the Notebooks, which continue to be a source of inspiration to the mathematicians of the world.

In February 1974, B.C. Berndt sought the Notebooks of Ramanujan in the library of Princeton University, to prove some results using a theorem he had proved earlier. This turned out to be the origin of Berndt's decade's long involvement with editing the Notebooks of Ramanujan, which contained more than 3000 entries, with the objective of researching into the originality of the same and providing proofs wherever they were required [13].

Srinivasa Ramanujan can be seen as a mathematical genius of the twentieth century. Due to the educational system he could not be creative in his own country and has spent the most fruitful years of his young life in Cambridge. Due to his illness he came back to India for passing away. His valuable heritage, the Notebooks, is back in Madras, where they have come into being.

Subrahmanyan Chandrasekhar (1910-1995) was known throughout his life as **Chandra.** His father was C. Subrahmanyan Ayyar and his mother was Sitalaksmi Aiyar. His father, an Indian government auditor whose job was to audit the Northwest Railways, came from a Brahman family which owned some land near Madras, India. Chandra came from a large family, having two older sisters, three younger brothers and four younger sisters. When Chandra was still young his parents moved to Madras and, as he grew up, he was encouraged to seek an education which would see him following his father into government service. However Chandra wanted to be a scientist and his mother encouraged him to follow this route. He had a role model in his paternal uncle Sir Chandrasekhara Venkata Raman who went on to win the Nobel Prize in 1930 for his 1928 discovery of Raman scattering and the Raman Effect, which is a change in the wavelength of light occurring when a beam of light is deflected by molecules. Chandra studied at Presidency College, University of Madras, and he wrote his first research paper while still an undergraduate there. The paper was published in the *Proceedings of the Royal Society*. Also at Presidency College with Chandra was Lalitha Doraiswamy, who was the daughter of a family living close to where Chandra's family lived in Madras. They became engaged to marry at this time. Chandra obtained a scholarship from the Indian government to finance his studies in England, and in 1930 he left India to study at Trinity College, Cambridge, England. From 1933 to 1937 he undertook research at Cambridge, but he returned to India in 1936 to marry Lalitha on 11 September.
They returned to Cambridge in 1936 but in the following year Chandra joined the staff at the University of Chicago where he was to remain for the rest of his life. At first he worked in Yerkes Observatory, part of the Univer-

sity of Chicago in Wisconsin. Later he moved to work on the university campus in the city of Chicago. During World War II he worked in the Ballistic Research Laboratories at the Aberdeen Proving Ground in Maryland. Two reports, written in 1943, show the type of problems he was working on at this time: the first is *On the decay of plane shock waves* while the second is *The normal reflection of a blast wave.* He was honoured with being appointed Morton D. Hull distinguished service professor of the University of Chicago in 1952. Although by that time Chandra had been working in the United States for 15 years, neither he nor his wife had taken out citizenship earlier. However, both became American citizens in the following year and became very much integrated into the life of the country. When Chandra was offered a chair at Cambridge in 1964 he replied by return that he was not interested, so turning down a position which as a young man he would have found the most desirable.

Chandrasekhar published around 400 papers and many books. His research interests were exceptionally broad but we can divide them into topics and rough periods when he was concentrating on these particular topics. First he studied stellar structure, including the theory of white dwarfs, from 1929 to 1939, then stellar dynamics from 1939 to 1943. Next he looked at the theory of radiative transfer and the quantum theory of the negative ion of hydrogen from 1943 to 1950, followed by hydrodynamic and hydro magnetic stability from 1950 to 1961. During most of the 1960s he studied the equilibrium and the stability of ellipsoidal figures of equilibrium but during this period he also began work on topics from general relativity, the radiation reaction process, and the stability of relativistic stars. During the period from 1971 to 1983 he undertook research into the mathematical theory of black holes.

Chandrasekhar received many honours for his outstanding contributions some of which, such as the Nobel Prize for Physics in 1983, the Royal Society's Royal Medal of 1962 and their Copley Medal of 1984. We should also mention, however, that he was honoured with the Bruce medal of the Astronomical Society of the Pacific, the Henry Draper medal of the National Academy of Sciences (United States), and the Gold Medal of the Royal Astronomical Society.

Chandra retired in 1980 but continued to live in Chicago where he was made professor emeritus in 1985. He continued to give thought-provoking lectures such as *Newton and Michelangelo* which he delivered at the 1994 Meeting of Nobel Laureates held in Lindau. He compared Michelangelo's frescoes in the Sistine Chapel and Newton's *Principia* :

... in the larger context of whether there is any similarity in the motivations of scientists and artists in their respective creative quests.

Figure 14: Young Chandra

Figure 15: Chandrasekhar as an US citizen

Other lectures in a similar vein include *Shakespeare, Newton and Beethoven or patterns of creativity* and *The perception of beauty and the pursuit of science.*

Chandrasekhar remained active and published a final major book *Newton's Principia for the Common Reader* at 85 years of age in the final months of his life. Shortly after publication of this work he died from heart failure and was buried in Chicago. He was survived by his wife Lalitha. He was an ambassador of India, but his scientific activities all took place outside this country.

5. Leo Baekeland, a typical Flemish case [14]

One of the earliest synthetics that transformed the material basis of modern life was Bakelite, a polymeric plastic made from phenol and formaldehyde. **Leo Hendrik Baekeland** (1863–1944) invented Bakelite in 1907, and his inventive and entrepreneurial genius also propelled him into several other new chemical technological ventures at the turn of the twentieth century.

After completing his doctorate at the University of Ghent in his native Belgium, Baekeland taught for several years. In 1889, when he was twenty-six, he travelled to New York on a fellowship (that had also allowed him to visit

universities in England, Scotland, and Germany) to continue his study of chemistry; Professor Charles F. Chandler of Columbia University then persuaded Baekeland to stay in the United States and recommended him for a position at a New York photographic supply house. This experience led him a few years later, when he was working as an independent consultant, to invent Velox, an improved photographic paper that could be developed in gaslight rather than sunlight. In 1898 the Eastman Kodak Company purchased Baekeland's invention for a reputed $750,000, a sum that allowed him to spend the rest of his life in experimentation.

Baekeland next entered the field of electrochemistry. He visited Berlin briefly to update his knowledge of this new area of study, and he equipped his private laboratory on the grounds of his home in Yonkers, New York, with a few electrochemical appliances. At the request of Elon Hooker, Baekeland cooperated with Clinton P. Townsend, the inventor of a new electrolytic cell for producing caustic soda and chlorine from salt, in setting up a pilot plant at the Brooklyn Edison Station. The success of their experiment led Elon Hooker to form Hooker Electrochemical Company in Niagara Falls—now part of the Oxychem subsidiary of Occidental Petroleum.

When friends asked Baekeland how he entered the field of synthetic resins, he answered that he had chosen it deliberately, looking for a way to make money. Chemists had begun to recognize that many of the natural resins and fibbers useful for coatings, adhesives, woven fabrics, and the like were polymers (large molecules made up of repeating structural units), and they had begun to search for combinations of reagents that would react to form *synthetic* polymers. Baekeland began to investigate the reactions of phenol and formaldehyde, and first produced soluble phenol-formaldehyde shellac called "Novolak," which never became a market success. Then he turned to developing a binder for asbestos, which at that time was moulded with hard natural rubber. By carefully controlling the pressure and temperature applied to an intermediate made from the two reagents, he could produce a polymer that, when mixed with fillers, produced a hard mouldable plastic. Bakelite, though relatively expensive, was soon found to have many uses, especially in the rapidly growing automobile and radio industries. Baekeland retired in 1939 to sail his yacht, the *Ion*, among other activities, and sold his successful plastics company to the Union Carbide and Carbon Corporation. Five year later, in 1944, Leo Baekeland died at the age of 80 years.

Baekeland was the son of a rather poor shoemaker. Because of his excellent study results he received from the Belgian community a scholarship to study. Being that good he left his country for the US and he is one of the typical examples of the first brain drain in Belgium.

Figure 16: Leo Hendrik Baekeland

6. The escape out of Europe of Jewish scientists during the Nazi-regime

In April 1933 Hitler's first anti-Jewish law was promulgated, stripping all "non-Aryan" academics of their teaching posts. The new law abruptly stripped a quarter of the physicists in Germany, including eleven who had earned or would earn Nobel Prizes, of their positions and their livelihood. Emigration was the only solution.
Some with extreme foresight, saw what the political landscape was to become and made early plans accordingly. Einstein was one of the first to go.
Around 1886 **Albert Einstein** [15] (1879-1955) began his school career in Munich. As well as his violin lessons, which he had from age six to age thirteen, he also had religious education at home where he was taught Judaism. Two years later he entered the Luitpold Gymnasium and after this his religious education was given at school. He studied mathematics, in particular the calculus, beginning around 1891.
In 1894 Einstein's family moved to Milan but Einstein remained in Munich.

In 1895 Einstein failed an examination that would have allowed him to study for a diploma as an electrical engineer at the Eidgenössische Technische Hochschule in Zurich. Einstein renounced German citizenship in 1896 and was to be stateless for a number of years. He did not even apply for Swiss citizenship until 1899, citizenship being granted in 1901.
Following the failing of the entrance exam to the ETH, Einstein attended secondary school at Aarau planning to use this route to enter the ETH in Zurich. Indeed Einstein succeeded with his plan graduating in 1900 as a teacher of mathematics and physics. Einstein worked in the patent office in Bern from 1902 to 1909, holding a temporary post when he was first appointed, but by 1904 the position was made permanent and in 1906 he was promoted to technical expert second class. While in the Bern patent office he completed an astonishing range of theoretical physics publications, written in his spare time without the benefit of close contact with scientific literature or colleagues.

Figure 17: Young Einstein

Figure 18: Einstein in his Princeton's period

Einstein earned a doctorate from the University of Zurich in 1905 for a thesis *On a new determination of molecular dimensions.* In the first of three papers, all written in 1905, Einstein examined the phenomenon discovered by Max Planck, according to which electromagnetic energy seemed to be emitted from radiating objects in discrete quantities. Einstein's second 1905 paper proposed what is today called the special theory of relativity. He based his new theory on a reinterpretation of the classical principle of relativity, namely that the laws of physics had to have the same form in any frame of reference. As a second fundamental hypothesis, Einstein assumed that the speed of light remained constant in all frames of reference, as required by Maxwell's theory. The third of Einstein's papers of 1905 concerned statistical mechanics.

By 1909 Einstein was recognised as a leading scientific thinker and in that year he resigned from the patent office. He was appointed a full professor at the Karl-Ferdinand University in Prague in 1911. He moved from Prague to Zurich in 1912 to take up a chair at the Eidgenössische Technische Hochschule in Zurich. Einstein returned to Germany in 1914 but did not reapply for German citizenship. What he accepted was an impressive offer. It was a research position in the Prussian Academy of Sciences together with a chair (but no teaching duties) at the University of Berlin. He was also offered the directorship of the Kaiser Wilhelm Institute of Physics in Berlin which was about to be established.

In 1920 Einstein's lectures in Berlin were disrupted by demonstrations which, although officially denied, were almost certainly anti-Jewish. During 1921 Einstein made his first visit to the United States. His main reason was to raise funds for the planned Hebrew University of Jerusalem. However he received the Barnard Medal during his visit and lectured several times on relativity. Einstein received the Nobel Prize in 1921 but not for relativity rather for his 1905 work on the photoelectric effect. In fact he was not present in December 1922 to receive the prize being on a voyage to Japan. Around this time he made many international visits, to Paris, Palestine, and South America.

By 1930 he was making international visits again, back to the United States. A third visit to the United States in 1932 was followed by the offer of a post at Princeton. The idea was that Einstein would spend seven months a year in Berlin, five months at Princeton. Einstein accepted and left Germany in December 1932 for the United States. The following month the Nazis came to power in Germany and Einstein was never to return there. During 1933 Einstein travelled in Europe visiting Oxford, Glasgow, Brussels and Zurich. Offers of academic posts which he had found it so hard to get in 1901, were plentiful. He received offers from Jerusalem, Leiden, Oxford, Madrid and Paris.

What was intended only as a visit became a permanent arrangement by 1935 when he applied and was granted permanent residency in the United States. In 1940 Einstein became a citizen of the United States, but chose to retain his Swiss citizenship. He made many contributions to peace during his life. By 1949 Einstein was unwell. A spell in hospital helped him recover but he began to prepare for death by drawing up his will in 1950. He left his scientific papers to the Hebrew University in Jerusalem, One week before his death Einstein signed his last letter. It was a letter to Bertrand Russell in which he agreed that his name should go on a manifesto urging all nations to give up nuclear weapons. It is fitting that one of his last acts was to argue, as he had done all his life, for international peace. Einstein was cremated at Trenton, New Jersey at 4 pm on 18 April 1955 (the day of his death). His ashes were scattered at an undisclosed place.

Several Hungarian Jewish scientists were also leaving Nazi-Europe, we give a short review hereafter and give a small bibliography of a few of them. There were many others.

Theodore von Karman [16] (1881-1963), born in Budapest studied at the Palatine Joseph Polytechnic in Budapest. In 1906 he was awarded a two year fellowship from the Hungarian Academy of Sciences and he left Budapest for Göttingen He was very much interested in aeronautics and he had a real chance to introduce this area as a research topic with the construction of a wind tunnel for the Zeppelin airship company. In 1913 Karman accepted a post as director of the Aeronautical Institute in Aachen. He began theoretical work on aircraft design. Karman visited the USA in 1926, at the invitation of the head of the California institute of Technology, to advise on the design of a wind tunnel. By 1928 he was spending six months each year at Caltech and six months at Aachen, then in 1930 he was asked to be the full-time director of the Aeronautical Laboratory at California Institute of Technology. Despite his love for Aachen, the political events in Germany and in particular the rising anti-Semitism persuaded him to accept. His mother and younger sister went to California with him. In 1933 he founded the U.S. Institute of Aeronautical Sciences continuing his research on fluid mechanics, turbulence theory and supersonic flight. He studied applications of mathematics to engineering, aircraft structures and soil erosion. His work turned towards research on rockets and, when Germany were seen to have developed rockets for military purposes during World War II, the United States Government put large sums of money into rocket research. In November 1944 the funding was used to set up the Jet Propulsion Laboratory at Caltech with Karman as

director. This laboratory later made major contributions to the space programme. In 1949 he resigned his two positions of director and became professor emeritus at Caltech. He was still very active in giving advice to the U.S. air force and NATO and played a major role in international conferences on aeronautics. He died in Aachen in 1963.

Figure 19: Von Karman

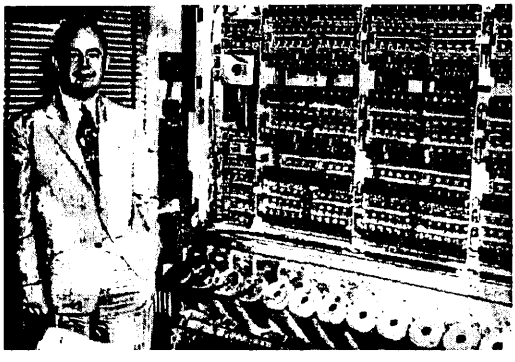


Figure 20: von Neumann and one of the first computers

John von Neumann [17] (1903-1957) was born János von Neumann. His father, Max Neumann, was a top banker and he was brought up in an extended family, living in Budapest. Although the family were Jewish, Max Neumann did not observe the strict practices of that religion and the household seemed to mix Jewish and Christian traditions. In 1911 von Neumann entered the Lutheran Gymnasium. The school had a strong academic tradition which seemed to count for more than the religious affiliation both in the Neumann's eyes and in those of the school. His mathematics teacher quickly recognised von Neumann's genius and special tuition was put on for him. The school had another outstanding mathematician one year ahead of von Neumann, namely Eugene Wigner. In 1921 von Neumann completed his education at the Lutheran Gymnasium. Von Neumann studied chemistry at the University of Berlin until 1923 when he went to Zurich. He achieved outstanding results in the mathematics examinations at the University of Budapest despite not attending any courses. Von Neumann received his diploma in chemical engineering from the Technische Hochschule in Zürich in 1926. Von Neumann

lectured at Berlin from 1926 to 1929 and at Hamburg from 1929 to 1930. However he also held a Rockefeller Fellowship to enable him to undertake postdoctoral studies at the University of Göttingen. In 1930 von Neumann became a visiting lecturer at Princeton University, being appointed professor there in 1931. He became one of the mathematics professors in 1933 at the newly founded Institute for Advanced Study in Princeton, a position he kept for the remainder of his life. During the first years that he was in the United States, von Neumann continued to return to Europe during the summers. Until 1933 he still held academic posts in Germany but resigned these when the Nazis came to power. Unlike many others, von Neumann was not a political refugee but rather he went to the United States mainly because he thought that the prospect of academic positions there was better than in Germany. Von Neumann was one of the pioneers of computer science making significant contributions to the development of logical design. He died in Washington D.C. in 1957.

The father, Antal Wigner, of **Eugene Paul Wigner** [18] (1902-1995) was the director of a leather-tanning factory while his mother, Erzsébet Wigner, looked after the family of three children. Both Antal and Erzsébet were from a Jewish background but they did not practice Judaism. In 1915 Wigner entered the Lutheran High School in Budapest. Here he met John von Neumann who was in the class below him. The school provided a solid education for Wigner in mathematics, literature, classics and religion. It did provide science teaching, but there was less emphasis on this than on other subjects. He was still at the Gymnasium when the communists took control in Hungary in March 1919 and the whole Wigner family fled the country. They lived in Austria until the communists were overthrown in November 1919 when they returned to Budapest and Wigner completed his school education. When he was in his late teens the whole Wigner family became converts to Lutheranism but it did not mean a great deal to Wigner who in later life described himself as "only mildly religious". In 1920 Wigner left school being one of the top students in his class. Already he knew that mathematics and physics were the topics for him. Now Wigner wanted to be a physicist but his father expected him to join the family business and he believed that a degree in chemical engineering would be useful to his son in the family's leather-tanning factory. Wigner followed his father's wishes and took his first degree in chemical engineering spending one year at the Technical Institute in Budapest, then moving to the Technische Hochschule in Berlin. Having completed his doctorate, Wigner returned to Budapest to join his father's tannery firm as planned in 1925. However, things did not go too well and he returned

to Berlin to accept an assistant position. Wigner was invited to Göttingen in 1927 to become Hilbert's assistant. Hilbert, already interested in quantum mechanics, felt that he needed a physicist as an assistant to complement his own expertise. This was an important time for Wigner who produced papers of great depth and significance. Wigner returned to Berlin after the year in Göttingen where he lectured on quantum mechanics, worked on writing his famous text *Group theory and its application to the quantum mechanics of atomic spectra* and continued his research. An offer to spend a term in Princeton saw him travel to the United States at the end of 1930. From 1930 to 1933 Wigner spent part of the year at Princeton, part at Berlin. His Berlin post vanished under the Nazi rules passed in 1933 and from then, except for the years 1936-1938 in Wisconsin, Wigner spent the rest of his career at Princeton. Wigner never really felt at home. Near the end of his life he wrote: *After 60 years in the United States I am still more Hungarian than American. ... much of American culture escapes me.*
Wigner received the Nobel Prize for Physics in 1963. He died in Princeton in 1995.

Figure 21: Eugene Wigner

Figure 22: Edward Teller

Edward Teller [19] (1908-2003) is born in Budapest, Hungary, in 1908. He received his university training in Germany and completed his Ph.D. in phys-

ics under Werner Heisenberg in 1930 at the University of Leipzig. In 1934, under the auspices of the Jewish Rescue Committee, Teller served as a lecturer at the University of London. He spent two years as a research associate at the University of Göttingen, followed by a year as a Rockefeller fellow with Niels Bohr in Copenhagen. In 1935, Teller and his wife came to the United States, where he held, until 1941, a professorship at George Washington University. The Tellers became U.S. citizens in 1941. In 1946, he became a professor of physics at the University of Chicago but returned to Los Alamos Scientific Laboratory in 1949, where he was also active during the war. From 1954 to 1958, he served as Associate Director at the new Lawrence Livermore Laboratory. He became a consultant to the laboratory in 1952. He was director of the Lawrence Livermore Laboratory from 1958 to 1960, at which time he accepted a joint appointment as a professor of physics at the University of California and as associate director of the laboratory. He held these posts until his retirement in 1975. He continued as a consultant at the Lawrence Livermore National Laboratory. Teller was most widely known for his significant contributions to the first demonstration of thermonuclear energy; in addition he added to the knowledge of quantum theory, molecular physics, and astrophysics. He served as a member of the General Advisory Committee of the U.S. Atomic Energy Commission from 1956 to 1958 and was chairman of the first Nuclear Reaction Safeguard Committee. He died in 2003.

Most of the above cited scientists were involved in the so-called Manhattan project. On 2nd August, 1939, three Jewish scientists Albert Einstein, Leo Szilard and Eugene Wigner, wrote a joint letter to President Franklin D. Roosevelt, about the developments that had been taking place in nuclear physics. They warned Roosevelt that scientists in Nazi Germany were working on the possibility of using uranium to produce nuclear weapons. Roosevelt responded by setting up a scientific advisory committee to investigate the matter. He also had talks with the British government about ways of sabotaging the German efforts to produce nuclear weapons. In 1942 the Manhattan Engineer Project was set up in the United States under the command of Brigadier General Leslie Groves. Scientists recruited to produce an atom bomb included Robert Oppenheimer (USA) and also, Eugene Wigner and Edward Teller, amongst many others. The scientists working on the Manhattan Project were developing atom bombs using uranium and plutonium. The first three completed bombs were successfully tested at Alamogordo, New Mexico on 16th July, 1945. On 6th August 1945, a B29 bomber dropped an atom bomb on Hiroshima. It has been estimated that over the

years around 200,000 people have died as a result of this bomb being dropped. Japan did not surrender immediately and a second bomb was dropped on Nagasaki three days later. On 10th August the Japanese surrendered. The Second World War was over. The contribution to this victory of the Jewish scientists was tremendous.

7. Operation paperclip after the Second World War

The *Operation Paperclip* [20] is closely connected to the figure of **Wernher von Braun**. Wernher Von Braun was one of the world's first and foremost rocket engineers and a leading authority on space travel. Wernher von Braun was the second of three sons born to Baron Magnus von Braun and Baroness Emmy von Quistorp. Born March 23,1912 in Wirsitz, Posen, Wernher was always a visionary. After reading Hermann Oberth's *Rocket into Planetary Space*, and the gift of a telescope from his mother, he decided to become a space pioneer and physicist. Later, he enrolled at the Berlin Institute of Technology in 1930. In 1932, at the age of 20, he received his bachelor's degree in mechanical engineering, and was offered a grant to conduct and develop scientific investigations on liquid-fuelled rocket engines. Two years later, Wernher received his PhD in physics from the University of Berlin.
In the early 1930's the German military was searching for a weapon which would not violate the Versailles Treaty of World War I, and at the same time defend Germany. Artillery captain Walter Dornberger was assigned to investigate the feasibility of using rockets. Dornberger went to see the VfR (Verein für Raumschiffahrt) and, being impressed with their enthusiasm, gave them $400 to build a rocket. Wernher von Braun worked through the spring and summer of 1932, only to have the rocket fail when tested in front of the military. However, Dornberger was impressed with von Braun and hired him to lead the military's rocket artillery unit. By 1934 von Braun and Dornberger had a team of 80 engineers building rockets in Kummersdorf, about 60 miles south of Berlin. Von Braun's natural talents as a leader shone, as well as his ability to assimilate great quantities of data while keeping in mind the big picture. With the successful launch of two rockets, Max and Moritz, in 1934, von Braun's proposal to work on a jet-assisted take-off device for heavy bombers and all-rocket fighters was granted. However, Kummersdorf was too small for the task, so a new facility had to be built.
Peenemunde, located on the Baltic coast, was chosen as the new site. Peenemunde was large enough to launch and monitor rockets over ranges up to about 200 miles, with optical and electric observing instruments along the

trajectory, with no risk of harming people and property. By now Hitler had taken over Germany and Herman Goering ruled the Luftwaffe. Dornberger held a public test of the A-2 which was greatly successful. Funding continued to flow to von Braun's team, developing the A-3 and finally the A-4.
In 1943 Hitler decided to use the A-4 as a "vengeance weapon," and the group found themselves developing the A-4 to rain explosives on London. Fourteen months after Hitler ordered it into production, the first combat A-4, now called the V-2, was launched toward Western Europe on September 7, 1944. When the first V-2 hit London von Braun remarked to his colleagues, "The rocket worked perfectly except for landing on the wrong planet."
The SS and the Gestapo arrested von Braun for crimes against the state because he persisted in talking about building rockets which would go into orbit around the Earth and perhaps go to the Moon. His crime was indulging in frivolous dreams when he should have been concentrating on building bigger rocket bombs for the Nazi war machine. Dornberger convinced the SS and the Gestapo to release von Braun because without him there would be no V-2 and Hitler would have them all shot.

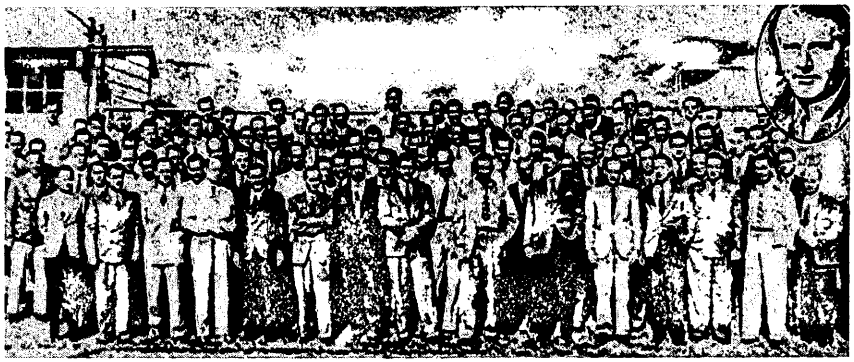


Figure 23: The group of scientists belonging to the operation paperclip

On arriving back at Peenemunde, von Braun immediately assembled his planning staff and asked them to decide how and to whom they should surrender. Most of the scientists were frightened of the Russians, they felt the French would treat them like slaves, and the British did not have enough money to afford a rocket program. That left the Americans. After stealing a train with forged papers, von Braun led 500 people through war-torn Germany to surrender to the Americans. The SS were issued orders to kill the

German engineers, who hid their notes in a mine shaft and evaded their own army while searching for the Americans. Finally, the team found an American private and surrendered to him. Realizing the importance of these engineers, the Americans immediately went to Peenemunde and Nordhausen and captured all of the remaining V-2's and V-2 parts, then destroyed both places with explosives. The Americans brought over 300 train car loads of spare V-2 parts to the United States. Much of von Braun's production team was captured by the Russians.

On June 20, 1945, U.S. Secretary of State Cordell Hull approved the transfer of von Braun's German rocket specialists. This transfer was known as Operation Paperclip because, of the large number of Germans stationed at Army Ordnance, the paperwork of those selected to come to the United States were indicated by paperclips.

They arrived in the United States at New Castle Army Air Base, just south of Wilmington, DE. Afterwards, they were flown to Boston, and then taken by boat to an Army Intelligence Service post at Fort Strong in Boston Harbor. Later, with the exception of von Braun, the men were transferred to Aberdeen Proving Grounds in Maryland to sort out the Peenemunde documents. Those documents would enable the scientists to continue their rocketry experiments where they had left off.

Finally, von Braun and the 126 Peenemunders were transferred to their new home at Fort Bliss, Texas, a large Army installation just north of El Paso, under the command of Major James P. Hamill. They found themselves in a strange situation as they began their new lives in America. Because they could not leave Fort Bliss without a military escort, they sometimes referred to themselves as "PoPs", Prisoners of Peace.

While at Fort Bliss, they were tasked to train military, industrial, and university personnel in the intricacies of rockets and guided missiles and to help refurbish, assemble, and launch a number of V-2's that had been shipped from Germany to the White Sands Proving Grounds in New Mexico. Further, they were to study the future potential of rockets for military and research applications. In 1950, von Braun and his team were transferred to Huntsville, Alabama, his home for the next twenty years. Between 1950 and 1956, von Braun led the Army's development team at Redstone Arsenal, resulting in the Arsenal's namesake: the Redstone rocket.

As Director of the Development Operations Division of the Army Ballistic Missile Agency (ABMA), von Braun's team then developed the Jupiter-C, a modified Redstone rocket. The Jupiter-C successfully launched the western hemisphere's first satellite, Explorer 1, on January 31, 1958. This event sig-

naled the birth of America's space program. NASA was established by law on July 29, 1958. One day later, the 50th Redstone rocket was successfully fired off Johnson Island in the South Pacific as part of Project Hardtack. Two years later NASA opened the new Marshall Space Flight Center in Huntsville, Alabama and transferred von Braun and his development team from the ABMA at Redstone Arsenal to NASA. Dr. von Braun was the center's first Director, from July 1960 to February 1970. The Marshall Center's first major program was development of the Saturn rockets, capable of carrying astronauts to the moon. Von Braun's childhood commitment to "turn the wheel of time," and his later dream to help mankind set foot on the moon became a reality on July 16, 1969 when a Marshall-developed Saturn V rocket launched the crew of Apollo 11. Over the course of the Apollo program, six teams of astronauts explored the surface of our moon. After the Apollo program, the Saturn 1B, also developed at Marshall under von Braun's leadership, lifted the Skylab, the world's first space station, and its crews into orbit. The final use of the Saturn was during the historic Apollo-Soyuz mission in 1975, when an Apollo spacecraft linked up with a Russian Soyuz craft. After the Apollo space program, von Braun felt that his vision for future spaceflight was different than NASA's, and he retired in June 1972. He became the vice-present of Fairchild Industries in Germantown, Maryland, where he was active in establishing and promoting the National Space Institute.
At the peak of his activities, von Braun learned he had cancer. Despite surgery, the cancer progressed, forcing him to retire from Fairchild on December 31, 1976. On June 16, 1977, Wernher von Braun died in Alexandria, Virginia
The brain drain of the German rocket specialists to the US was the start of the space program of that country.

8. Some conclusions

Through history brain drain has always existed. We have demonstrated this phenomenon with the help of some examples situated a long time ago and in the near past. Scientists always have tried to work in the most comfortable surroundings. Their moving to such place is governed sometimes by financial reasons – obtaining a consistent grant, having at one's disposal of an adequate research budget -, but also religious, political and economic reasons are lying at the basis of a displacement of scientists. One can put forward that the present brain drain from the European countries to the US is nothing new under the sun, but should be studied by our politicians and acceptable meas-

ures should be taken. In this context we can refer to the recent initiatives of the Flemish Government, where the Odysseus and Methusalem programs have been started up, by which one hopes to bring back to Flanders researchers for the moment active in foreign countries.

Notes

[1] Statement mentioned in "RTD info, Magazine for European Research, special edition, August 2003, p.23".

[2] Time, January 19, 2004, p.35.

3. Most material has been adapted from the information available on the website http://www-groups.dcs.st-and.ac.uk. and in Al-Daffa (Ali Abdullah) - *The Muslim Contribution to Mathematics, Croom Helm - London, Humanities Press, Atlantic Highlands, N.J., 1977.*

[4] Umberto Eco, *The Name of the Rose,* San Diego, Harcourt Brace & Company, 1994.

[5] For this chapter we were inspired in general by *Geschiedenis van de wetenschappen in België van de Oudheid tot 1815*, (Gemeentekrediet, Groep Dexia, 1998), in particular by Chapter 2 (De Wiskunde, by Paul Bockstaele), Chapter 3 (De Kosmologie, Van Gemma Frisius tot Wendelen, by Fernand Hallyn), Chapter 4 (De natuurkunde, by Patricia Radelet-de Grave), Chapter 5 (De cartografie, by Hossam Elkhadem).

[6] G Kish, *Medicina, mensura, mathematica : The Life and Works of Gemma Frisius, 1508-1555* (Minneapolis, 1967).

[7] Nicolas Crane, Mercator, de man die de aarde in kaart bracht, Ambo – Manteau 2002.

[8] Interesting historical facts about the foundation of the University of Leiden and the first period of working can be found in *Libelli introductorii ab Ricardo Vulpitio composite* (anno MCMLXXV), document available at the exhibition on the University of Leiden in the main building at Rapenburg (Leiden).

[9] Jozef T. Devreese en Guido Vanden Berghe, *'Wonder is gheen wonder', De*

geniale wereld van Simon Stevin 1548 – 1620, Davidsfonds 2003.

[10] R. Kanigel, R. 1991. *The Man who Knew Infinity: A Life of the Genius Ramanujan*, Charles Scribner's Sons New-York (also Indian edition, Rupa & Co (1994)).

[11] Notebooks of Srinivasa Ramanujan, 1957, Facsimile edition, Tata Institute of Fundamental Research, Bombay, vol 1 and 2.

[12] G. H. Hardy,. 1923. A Chapter from Ramanujan's Notebook, *Proceedings. of the Cambridge Philosophical Society*, **21**, 492--503. See also, G.H. Hardy. 1924. Some Formulae of Ramanujan, Proceedings of the London Mathematical Society, **22**, xii--xiii.

[13] B. C. Berndt, *Ramanujan's Notebooks*, Part I (1985), Part II (1989), Part III (1991), Part IV (1994), Part V (1997), Springer-Verlag New York Inc.

[14] see for example in *Geschiedenis van de wetenschappen in België, 1815-2000,* (Dexia 2001), in particular Chapter 13 (De industriële scheikunde, by Philippe Tomsin).

[15] See for example bibliography in *Dictionary of Scientific Biography* (New-York 1970 – 1990).

[16] S. Goldstein, Theodore von Karman, 1881 – 1963, Biblographical Memoirs of Fellows of the Royal Society of London 12 (1966), 335 – 365.

[17] W Aspray, *John von Neumann and the origins of modern computing* (Cambridge, M., 1990).

[18] See Biography in Encyclopaedia Britannica.

[19] S.A. Blumberg and G. Owens, *Energy and Conflict: The Life and Times of Edward Teller,* (New York: Plenum Press, 1976).

[20] C.G. Lasby, *Project Paperclip: German Scientists and the Cold War*, (Scribner , 1975).