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Sarton Chair of the History of Science
Ghent University, Belgium

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Editors: Robert Rubens and Maarten Van Dyck

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Introduction.

R.Rubens - August 2022

Due to the covid pandemic the Sarton Chair had to be interrupted during the academic year 2020-21. Luckily we could restart in the second part of the academic year 2021-22 and tried to recuperate the missing lectures. Therefore the volume you will be reading has been numbered 34-35 as it contains the lectures of two academic years.

Based upon the Sarton tradition the lectures are again devoted to all aspects of human science. We hope therefore they may interest a broad audience.

Begining we have the argumentative essay for the humanities in the laudatio of the chairholder and medal recipient of the faculty of Arts by Yves T'Sjoen breaking a lance for the paramount value of the humanities in education.

As a starter we had the Sarton Chair devoted to the "ideal historian of science" written by F.Cohen; In that paper he carefully dissects the portrait of the academic historian having different aspects: sources and literature, language and concepts, reasoning and methodological aspects of the history of science.

The following paper by Mathijsen, the medal recipient, gives a nice outline and study about the popularisation and democratisation of science and culture in the nineteenth century. The detailed study using examples as well from the Netherlands as Belgium provides a detailed insight in the different aspects.

The Graham Island case by Gerkens demonstrates how old Roman Law still can be useful in nowadays problems and proves that the collection of laws by Gaius is still very important in legal history. The “occupatio” rule is nicely explained based upon the example of the vanishing island before the Sicilian coast.

The lecture of Vandamme synthetizes the old history of spontaneous generation, now totally discredited, together with a modern view on the origin of life on our planet. Although not every step is now yet nicely documented the LUCA hypothesis seems the most probable. In this way modern science seems to recreate a new but otherwise documented “spontaneous” creation of life.

The historical and social narrative of Vandenbroeck depicts an overview and explains how the evolution of the pedagogy of the young child in the twentieth century can only be understood if social history is taken into account. It starts with the eugenic view followed by the evolution towards the economic history but with the addition of the basic neurosciences in the last two decades.

The history of veterinary obstetrics has been written by an international expert in the field of cow obstetrics. De Kruyf accurately describes the succeeding methods during centuries for helping the large mammals in husbandry to drop its young.

In the history of dialysis two subjects are developed. First an overview of kidney disease during the ages is outlined. The second part is devoted to the history of the different methods used to replace the failing kidney function.

Y.Cassis nicely describes the financial history of Europe in the twentieth century. It contains an outline of the evolution of the financial centres and institutions in the old continent. It stresses the importance of the banking systems and changes ending in an international integration at the end of the century.

The lecture by Van Leeuwen not only highlights the different centres, authors and places active in research about tribology in the Low Countries but it also contains the original story of the discipline. Probably unknown to most a maior contribution was also made by important mathematicians in the Golden Age of the Dutch Republic.

De Dapper explains the origin of geoarchaelogy with its evolution the previous half century. The new discipline founds its roots in the department of geography and uses the most recent advances in soil science to help archeology.

May we express again the hope that the lectures contained in this volume many researchers can inspire not only to look for new results but also to cherish the already discovered important methods and facts by their predecessors.

Laudatio Cohen and Mathijsen

Y.T'Sjoen

After the foreword from the Dean, Prof. Dr. Gita Deneckere and Prof. Rubens, by way of introducing Professor Cohen's and Professor Mathijsen's lectures, allow me first to briefly underline the importance of the humanities and social sciences in society. I will then turn to my colleague Marita Mathijsen, who, as already mentioned, will shortly be receiving the Sarton Scientific Medal in our faculty.

We share the same concerns as several other colleagues, including both honoured recipients of the Sarton Medals. For many years, Marita Mathijsen and Floris Cohen have, in their work, including more public-oriented contributions and public books, been committed to giving the humanities the prestige that the alpha sciences deserve. They think critically about the university of today and tomorrow. This aspect, too, in addition to academic merit, is being addressed at our university, in the Faculty of Arts and Humanities, in the context of the Sarton awards. Allow me to explain.

The purpose of social sciences and the humanities in society has long been the subject of debate. This debate is now being conducted with a certain degree of doggedness – and in some cases being fought tooth and nail – certainly amidst an intellectual crisis, falling student numbers, shrinking research funding and a declining base of support in society, at a juncture in time when education is predominantly focused on STEM subjects (Science, Engineering, Technology and Mathematics). Usually, the relevance of the humanities is questioned from a neo-liberal and economic point of view, or – put differently – in terms of market-economic thinking. The use of a humanities degree is publicly being questioned these days. The key question is, of course, how the importance, usefulness and, therefore, relevance of a discipline of science is defined, what is described as 'useful'.

Social sciences and the humanities – in Anglo-American-oriented Western academia usually referred to by the umbrella term Humanities – are a collective term for diverse fields of science, such as philosophy and language studies, art, music and theatre studies, history, translation, linguistics and literature. When the relative importance of the alpha sciences is emphasised, today more than ever before, our critics think mainly in terms of the "usefulness" of the applied sciences, the practice of science at the service of socio-economic profitability, of medical, architectural, legal, biochemical and other applications. Science as a useful instrument for problem-solving. But is it not much more? In the public debate conducted in the media, the importance of utility is assessed in a rather reductionist way. What is useful? Language, for example, or historical awareness, or philosophical reflection. And that is exactly what humanities scholars focus on. They devise models for thought processes, for the acquisition of insight, for example into how society operates (in the past, now and in future), what they find 'useful', they hone critical thinking and offer other perspectives on social, political-ideological and other problems.

What is usually overlooked in such discipline-related discussions is that humanities findings underlie many experiments and developments in the exact, or beta, sciences. In this respect, the humanities are crucial, if not decisive, in many cases, for what is being mined in other (beta or gamma) scientific disciplines, and for the research methods and findings that are used and presented by the so-called exact sciences. The much-debated usefulness of the humanities is then described as critical thinking, the art of challenging basic assumptions and points of view, the stirring up of something as special and vital as wonder, as well as the questioning of the perspective that makes the prismatic world multi-faceted, multi-layered and translatable.

Ghent University's Arts and Philosophy Faculty has been hosting a Humanities Think Tank since 2018. The Humanities Academy was inaugurated at the Book Tower's Belvedere in October last year. Researchers affiliated with various faculty departments enter into dialogue with each other about the past, present and future of humanities research. New perspectives are created; we are an activist group who passionately defend and promote the humanities with all our might. In the spring of 2021, on the occasion of the Faculty's Francqui Chair, Prof. Rens Bod, a specialist in the field of (the meta discourse on) the Humanities, was our discussion partner. In his international publications and lectures, he reflects on the history, challenges and especially the importance of the humanities in society. It is no coincidence that we are welcoming Prof. Marita Mathijsen and Prof. Floris Cohen today, both eminent Dutch emeriti professors with an interest in the history of science, something which dovetails with the Humanities Think Tank's objectives. In the meantime, Universitas, a series of discussions with representatives of the arts, sciences and the social sciences, has also been set up at Ghent University. Our colleagues from the other academic disciplines are by far the staunchest advocates of the importance of the humanities in society.

This is not on the basis of a stubborn, self-justifying position – in the form of an apology for the humanities or, as Rens Bod writes, on the basis of 'the image problem' – but proactively, in a quasi-activist way, reasoning on the basis of the strengths (and therefore also the demonstrable scientific and economic relevance in society) of our cherished and shared academic discipline.

It is, indeed, fundamental not to start from this now familiar *rigid* constellation. Along with the members of the Think Tank, we are conducting an open debate in the faculty about the necessity of the Humanities for world (contemplation), the aesthetic potential and concepts. In Marita Mathijsen's own words, we emphasise the "moral standard" and "secondary needs", or the art of reading and understanding, reasoning and reflection. Here, it is appropriate to refer to Floris Cohen's book *De ideale universiteit* [The Ideal University] (2019), which sees the humanities as the bedrock of university education and research. Thinking in terms of return is not foreign to alpha students either, albeit that "usefulness" for social thinking is articulated differently than it is in a beta environment. Knowledge areas that are considered part of the alpha domain, such as Digital Humanities, Environmental, Cognitive or Medical Humanities, are indispensable for a nuanced intellectual debate and the discussion about man and the world. Or, as Rens Bod puts it in his fabulous book *De vergeten wetenschappen* [The forgotten sciences]: without the humanities approach, insights and observations from the exact sciences would be well-nigh impossible, if not undesirable. What's more, they have transformed (the view of) the world and continue to do so.

"It is important that humanities scholars are aware of this and do not speak from the position of defence, but from the consciousness that without their input, society is in moral danger. The sciences are useful for man's primary needs, such as warmth, food, drink, absence of pain and survival. There are also secondary needs, including love, variety, beauty, intellectual challenge, awareness of patterns and insight into moral issues. To satisfy these, the alpha scientists are indispensable. Through university education, they can ensure a lasting influence both in the media and in politics. A society without humanities scholars in crucial positions is a society that should come with a word of caution." No doubt, today's Sarton invitees concur with this statement.

Ladies and gentlemen, dear colleagues, in view of the Sarton Committee's outspoken interest in the history of science, in Professor Mathijsen's case philology and scientific text editing, the faculty's research group Text Editing in Literature in Flanders has submitted Marita Mathijsen's nomination to the department of Literature, then to the faculty of Arts and Philosophy. The Sarton Committee endorsed the proposal and confirmed the nomination for the science award. Tomorrow, Christophe Verbruggen of the History Department will be introducing Prof. Cohen on behalf of both of us on the occasion of the acceptance of the Sarton Chair. Forgive me that today, at this faculty meeting, the spotlight of the laudatio is unilaterally directed at my dear, highly honoured and highly learned colleague Marita Mathijsen.

I am in no doubt that our guest of honour and laureate of the Sarton Medal needs little introduction. The scientific recognition and societal importance of both works has been mentioned and praised many times, but perhaps not as emphatically as today. Professor Mathijsen specialises in nineteenth-century Dutch literature, with, among other things, a standard work on Romanticism in the Netherlands, a hefty biography of Jacob van Lennep (*Een bezielde schavuit* [An inspired rogue], 2018) and last year, the highly acclaimed book *L. De lezer van de 19de eeuw* [The 19th-century reader], which, on the basis of extensive archival research, makes a valiant attempt at describing – and bringing to life – the readers, their reading expectations and the literary experience in the Netherlands in the nineteenth century. A companion volume on the Flemish reading contemporary is now urgently required. Moreover, Mathijsen is a specialist in modern editing. Her book *Naar de letter* [To the letter] is still a reference work in the field of editing research. In addition to theory, there is also practice. As a scientific text editor, she has, among other things, edited the annotated scientific letters of *De Schoolmeester* [The School Teacher] – at the time of her doctoral thesis – and also works by Harry Mulisch, Hans Faverey' poetry and many nineteenth-century texts.

The creative approach to her writing, such as fictitious conversations with nineteenth-century writers in *De geest van de* dichter [The poet's mind] (1990), as well as the thoroughness and accessibility with which the research is undertaken, in, for example, the meticulous study *De gemaskerde eeuw* (The masked century), with its history of the mentality of the nineteenth century, allow many readers to sample and share in the consistently delightful result of thorough scientific archival research. Prof. Mathijsen is not only an outstanding and exceptionally prolific academic researcher, she is also a gifted speaker and zealous publicist with an outstanding turn of phrase. She is regularly present in the media. Her reflections on the study of literature, on our treatment of literary and cultural heritage, on bibliophilia and, last but not least, on the humanities, and even more specifically on Dutch studies at universities from the nineteenth century to the present day, are highly recommended. She has filled several books with blogs and opinion pieces, columns and other private reflections in both *NRC Handelsblad* and *de Volkskrant*. Although published many years ago, *De afwezigheid van het verleden* [The absence of the past] (2007) and the collection of essays entitled *Vroeger is ook mooi* [The past is also beautiful], with valuable reflections, are commendable. Her musings on historical consciousness, on our rather frivolous treatment of the past, are pithy, and in any case always salient and stylistically appealing. What the delightful writer Alma Mathijsen wrote, included as a motto in *L. De lezer van de 19de eeuw* [The 19th century reader], is certainly pertinent: "Every book is an activist act. Something that lives in the mind of the writer has been alone too long, and is a cry to be heard". Like daughter, like mother.

For years as professor at the University of Amsterdam, now retired, Marita Mathijsen is not only an enthusiastic (guest) lecturer, but in the scientific field, she has brought colour and social prestige to literary Dutch literature in recent decades. What she recently wrote about the death of her former colleague at the University of Amsterdam and biographer Jan Fontijn also applies to the academic teaching she has imparted, the many hundreds of guest lectures she gave at home and abroad, along with the engaging style of writing in her extensive collection of books and articles.

In view of the unmistakable and numerous merits in the field of philology and the study of nineteenth-century literature and the history of mentality, the Faculty of Arts and Philosophy has unanimously nominated Prof. Mathijsen for the academic distinction that is being bestowed upon her today, after that long wait. Rather than listing all the normative and inspiring studies that the Sarton Medal laureate has dispatched into the world and with which she continues to delight readers, for the bibliography is impressively long, I would like to say that the academic and exceptionally readable cultural-historical study *Historiezucht*. *De obsessie met het verleden* [Historicism. The obsession with the past] (2013) can be seen as a very specific reason for the scientific tribute awarded by the Sarton Committee and Ghent University.

On behalf of the faculty and the Sarton Committee, I would like to once again warmly congratulate Professor-emeritus Marita Mathijsen and extend all praise from the south.

The ideal historian of science – A written polyptych

H. Floris Cohen

In this essay I sketch a multi-panel portrait of the ideal historian of science. The sketch is situated about half-way a pipe dream and a blueprint. The five-panel polyptych I shall be painting in words is not, I trust, the product of an imagination run rampant. But neither could, let alone should, the ideal historian of science I am about to outline stand for an actual person actually made of actual flesh and blood. The ideal sketch that follows may not, therefore, be mistaken for a cunningly hidden portrait of the author – has not the capacity to admire traits we know perfectly well we are lacking ourselves been built into our very upbringing? In the final section I shall portray the admired historian of science who has come closest to my ideal, and of whom I hope, whenever I have completed some piece of work, that, looking down from the height of his heavenly cloud upon our earthly doings, he will take note of it with some measure of of satisfaction.

Panel (1): Sources & literature

Ideally, all scholarly research starts with a question felt to be in urgent need of resolution. What, with the question firmly settled in mind, a historian of science then needs in the first place is an idea of what source materials are available to guide the investigation, and what writings should be consulted to help put these in their proper context.

Sources, of course, come in many ways. As historians of science we deal most often with sources in the guise of the written word (and often of the written number as well), even though there are also sources made up of spoken words laid down in writing later (notably in oral history), or of material remainders of the past (as for instance with astrolabes or microscopes). Not always do the written word and the written number come by way of neat archival records collected at one spot in some handily predetermined context, as with the Christiaan Huygens collection donated by his heirs to Leyden University Library. We may have to dig for them in widely spread and far-away places, as was the case with my grandfather Hendrik Cohen. A practicing pharmacist, he decided in the 1920s to write a doctoral dissertation with for subject the history of the Dutch medicinal herb garden. To that end he prepared a detailed questionnaire and sent it to dozens and dozens of regional and local archivists all over the Netherlands to find out – with considerable success – whether their collections, products all of record keeping along administrative criteria quite different from his own interest as an early historian of pharmacy, might nonetheless contain items dealing with medicinal herbs cultivated locally.[1] In our own day we happily believe that we can make do without any such effort, as the internet offers great opportunities for coming upon sources whose existence reveals itself to us thanks to automatically operating tools. In reaping the fruits we may, comfortably seated behind our desktop computers, forget perhaps a little too easily what riches this search method may still be hiding rather than revealing.

Among the diversity of sources, one variety few historians of science can do without is published editions of a scientist's collected works and (in many a case) letters as well. And indeed, numerous, perhaps most, text editions are marked by their textual reliability and by the historical sense displayed by the editors. One example, outstanding in my opinion, is Johannes Kepler's *Gesammelte Werke*, the first volume of which appeared in 1938 and the last in 2017 (all 22 volumes, spread over 26 tomes, are meanwhile available on the internet).[2] The edition comprises all published works by Kepler, as well as all his preserved manuscripts and letters. With the operation centered from beginning to end in Munich (where the initiative was taken in 1914), and overseen by a special Kepler committee, the editor to determine the overall setup of the series was Max Caspar (1880–1956). In eighteen far from easy years he managed to publish eleven volumes in all. Particularly praiseworthy in my opinion is the care with

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1 Hk. Cohen, *Bijdrage tot de geschiedenis der geneeskruidcultuur in Nederland*. Rotterdam: Brusse, 1927.

2 The website https://kepler.badw.de/geschichte.html provides all relevant data.

which Caspar distinguished between what should be in and what had better remain outside the series' volumes. Those that he edited himself contain very accurate renditions of original texts (most of them in Kepler's rather convoluted Latin), preceded and/or followed by accounts of the edited work's history and further by whatever might help the reader gain an understanding of the work or works edited in the volume in question. Not that what he thus left out left him indifferent; quite to the contrary. Outside the series proper Caspar prepared eminently accurate German translations of two of Kepler's most significant works, *Astronomia nova* and *Harmonike mundi*. He was likewise prudent enough to leave his vast knowledge about Kepler's life in general out of the series, reserving materials of that kind for a biography (entitled, simply, *Johannes Kepler*) that came out in 1947 and that (certainly in view of the state the discipline had by then attained) still stands out for its overall excellence.

Having thus already crossed the border between how to determine our source materials and where to find suitable literature, it is very much worth observing that in the latter respect we historians of science are particularly lucky. Thanks to the man after whom this yearbook is named, George Sarton, we have at our disposal an annual bibliographical tool that goes back to the very first issue of the very first specialized journal in the history of science. Its name was (and is) *Isis*, and it was founded by Sarton in 1912. In the programmatic piece of 44 untitled pages with which its first issue opens Sarton unfolded a very ample vision of the future he hoped to be in store for what he had every intention to turn into a full-fledged scholarly discipline. Among the most tangible portions of that vision was Sarton's ambition to provide the budding profession, through *Isis*, with the critical, well-informed, expertly written book reviews and the bibliographical wherewithal needed for quickly and reliably cutting a suitable pathway through the maze of all the books, journal articles, and studies of other kinds that had appeared, were appearing, and no doubt would year in year out keep appearing in many languages and covering a vast range of topics relevant one way or another to the history of science taken in the widest sense. Indeed, what Sarton started with *Isis* in 1912 is now, 110 years later, still the case in, at bottom, the same broad vein. *Isis* is still meant to publish, beside research articles and discussion forums, reviews of every even moderately significant book on the history of science broadly conceived, and every single issue testifies to how seriously this long-standing objective is still being met. Also, over meanwhile many decades every professional has at his beck and call a by and large exhaustive overview of every at all relevant publication that has appeared over the past year. Coming in the format of a *Current Bibliography* annually sent along with *Isis*' December issue, it counts over 300 pages (overseen by a professional Bibliographer, and meanwhile fully searchable the electronic way).

Surely there is more to the preparation of our research than the meanwhile customary collection of suitable looking titles through the internet. My impression is that it has become more and more usual to confine one's search to work published in recent or even very recent years. It may well be that much damage is being caused in this (as in just about every other) regard by the widely-spread habit of measuring research quality by counting references in journal issues of the last two (or, at best, five) years. In a scholarly discipline like ours the best that has been said about a given subject may on occasion be in work that came out decades ago – not, as a rule, for the full 100 % up-to-date, yet still extremely valuable due to the conceptual analysis or other special qualities of the piece of writing in question. Just one example of an exemplary literature search is Richard S. Westfall's Newton biography *Never at Rest*, which came out in 1980. Not only had Westfall (1924 – 1996) read every letter of all the millions of words ever written by Newton and preserved since, and this decades before the internet was even conceived of.[3] He also consulted every piece of literature worth taking even moderately seriously, earlier Newton biographies of by then more than a century old surely included.

Another relevant aspect of the literature search is that, on occasion, a study of the utmost relevance for one's investigation is, bibliographically speaking, so well hidden that one can learn about its very existence only the informal way, that is, through collegial encounter. For instance, by the mid-1980s I was on the lookout for studies about the question of how it is that modern science arose in Europe, not in the different yet in many ways also cognate civilization of Islam. Footnote references yielded some incidental pieces, which proved to be either quite brief or of dubious quality or both. A chance encounter on the street with a colleague of my acquaintance then wrought wonders, as he told me about the existence of a lengthy essay entitled 'The Causes of the Decline of Scientific Work in Islam'. It had

3 Westfall had to make do with either the original documents or with microfiche reproductions thereof. Over the past decade an exemplary Newton Project initiated and directed by Rob Iliffe has made all such efforts superflous: https://www.newtonproject.ox.ac.uk/.

been written by a certain Aydın Saylı (1913 – 1993), who on completion in 1942 of his Harvard doctoral dissertation under George Sarton's supervision had returned to Turkey. His essay appeared as 'Appendix II' of his 1960 book *The Observatory in Islam and its Place in the General History of the Observatory*, and indeed, hardly a more effective way to make one's own work bibliographically untraceable can be thought of. I would have been utterly unable, without collegial help, even to become aware of its very existence, which would have been the more regrettable as, on inspection, this by then already a quarter-century old piece about a historical question of burning interest to me appeared to be the most sensible, the most balanced, the least ideologically biased, the analytically most astute, and above all the most insightful study of them all.

This account leads naturally from *tracing* the literature we expect to come us in good stead to actually *reading* it. And yes, by 'reading' I mean 'reading', not 'diagonally scanning'. Surely, and for good reason, we habitually make our first acquaintance with a piece of literature the diagonal way, so as to attain a quick intuition of whether or not this particular publication will really prove worthy of our spending precious time on it. But if the answer is 'yes', then what? Then the thing to do is to immerse ourselves fully (though hardly uncritically) in whatever the text and nothing but the text proves to have to tell us. What is the author really aiming at; how does she seek to make her case? What means does she employ to render her argument compelling, or at least plausible? How about the relationship between the stance taken by the author and the empirical material she adduces to underpin it? In short (to cite the 12th-century neo-Confucian philosopher Zhu Xi): "In reading, don't strive for quantity. Instead become intimately familiar with what you do read."[4]

I found an early, instructive example in the work of Anneliese Maier (1905 – 1971). Emigrated in 1933 when she found that life in Germany under the nazi's was becoming "intolerable",[5] she lived and worked until her death thirty-five years later in Rome, where as an independent scholar in the Vatican library she examined ranges of 14th-century manuscripts on, notably, subjects in natural philosophy. Some twenty years earlier the devoutly

4 As quoted by Andrew Hui in his *A Theory of the Aphorism. From Confucius to Twitter*. Princeton UP, 2019; p. 95.

5 "... als es anfing unerträglich zu werden" (Anneliese Maier to E.J. Dijksterhuis, 28 June 1948; as quoted in my *The Scientific Revolution. A Historiographical Inquiry*. University of Chicago Press, 1994; p. 537.

Roman Catholic physicist Pierre Duhem had made quite a splash with an argument based on some of those 14th-century treatises, which had collectively remained unread for centuries until Duhem resurrected them. His argument came down to the radical thesis that modern science was not created by Galileo and his early 17th century contemporaries but three centuries earlier, in circles of priests and monks teaching philosophy in Duhem's beloved University of Paris. Maier now inspected the same texts without any such ideological blinkers, and went on carefully to demonstrate, along the pathway of accurately reading and expertly analyzing what these manuscripts were really saying, that even in the, for Duhem, most favorable interpretation one could speak at best of 14th-century 'forerunners' making a first step in a so far untried direction that was not until three centuries later to lead to effective revolution.[6]

And therefore: to remain open-minded in respect of unconventional finding places for our sources; further to obtain a solid grounding in the literature; to go farther back than just the most recent contributions; not to scan but patiently, attentively and with dedication to read so as to find out what an argument really comes down to – such habits already mark some major features of every serious scholar to be sure, but most certainly of our ideal historian of science.

There are, of course, more such features.

Panel (2): Language & the handling of concepts

Once again we consider first the historian of science as investigator, then as author. Our ideal historian of science masters many more languages than the one in which she or he has been raised. Of course, the ideal historian of science masters every language ever used by any scientist the world over. In his blessed absence the example of a native Austrian engineer by the name of Otto Neugebauer (1899 - 1990) will amply do. He lost his scholarly heart in succession to mathematics, to the history of mathematics, and to the history of mathematical astronomy. Far from finding his sources just around the corner, he encountered them in ancient Egypt and, at the next stage, in equally ancient Babylonia (with for outcome of the latter study three voluminous tomes *Mathematische Keilschrift-Texte*, published be-

6 I discussed Duhem's thesis and how Maier dealt with it in *The Scientific Revolution*, p. 45–59.

tween 1935 and 1937). As Neugebauer pursued his career further he began to transcribe and analyze as well sources in ancient Greek, in classical and medieval Latin, and even in an early Semitic language by the name of Ge‘ez, which he taught himself when already of senior age because he knew of manuscripts in that language that might help him resolve a certain problem in ancient astronomy. So much is certain: thanks to Neugebauer's efforts over half a century, views on mathematics and on mathematical astronomy in the ancient Mediterranean but also in medieval and even in Renaissance Europe have changed, almost beyond recognition, for the good.

Surely Neugebauer's ability to master so many long-extinct languages until well into his old age was quite exceptional. Speaking more generally, the importance for any historian of science to learn to read texts in other languages than just one's own rests in the circumstance that efforts at acquiring knowledge of the natural world have manifested themselves in so many nations and in so many civilizations. So much the worse the blinkered view we impose upon ourselves if in selecting and examining sources we have locked ourselves up in just one language, as is increasingly the case in, notably, the Anglosaxon world of scholarship.[7] The result is not only a blinkered view; we deliver ourselves helplessly to translations, the availability of which we cannot take for granted and the quality of which we cannot control – a control needed the more as professional translators are as a rule humanities people and not, therefore, particularly at ease with texts about science.

Back now for a moment to Neugebauer. Just as easily as he mastered one language after another for *reading* purposes did he switch from one *writing* language to another. He did so when by the end of the 1930s he left nazi Germany and established himself in the USA, never again to write even one word in German.[8] This readily brings me to how the ideal historian of science expresses herself in her role of author. I drop the issue of more languages than one, so as to discuss how the historian of science seeks in writing to get the contents of what she has to say across to the reading public. It goes almost without saying that certain limits are set to the liberty an author enjoys in this regard – journal editors may suggest or prescribe certain things and forbid others – yet in a discipline like the history of science the

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7 I discussed these issues in a piece 'English and its sister languages' for the British journal *Viewpoint*, no. 110 (available on www.hfcohen.com under 'Other Work / Translator').

8 All these data stem from Noel M. Swerdlow's piece 'Otto E. Neugebauer 1899–1990. A Biographical Memoir'. National Academies Press (Washington DC), 1998 (pdf found on the internet).

author ususally has quite some leeway. He may opt for so-called academic writing, that is to say, for a yawn-provoking opening sentence in the vein of ‘Recently important research has been undertaken on thisorthat’; for sentences that cover at least ten lines; for passive sentence constructions; for piles of acronyms and at least three-syllabic, Latinate substantives, and for a maximum of jargon and of ostentation of personal learning. But she may also opt for a writing style directed rather at gaining, and then not losing, the reader’s attention with the large variety of stylistic means available for the purpose. I encountered a well-nigh ideal example in a comment by Richard S. Westfall on Robert Boyle. In a sentence instantly recognizable for anyone who has ever been struggling with a text by Boyle, he referred in passing to “Boyle’s inability to bring a sentence to a successful conclusion.”[9] It is not even so easy to pinpoint exactly what it is that has made this line stick in memory forever – I need only see Boyle’s *name* mentioned or that one ultra-apt phrase turns up the same second. Indeed, Westfall’s work as a whole constitutes academic prose at its very best– so alive, so crystal-clear, so pungent,[10] succeeding so well in keeping the reader involved in what the author has to say. If only I possessed his gift for exactly ‘le mot juste’ at exactly the right moment!

Nothing of all this takes away the truism that there is and remains a difference between writing for one’s co-professionals chiefly (as Westfall did as a rule) and writing for larger audiences. In my opinion, we professors should spend at least one sabbatical leave writing up a broadly accessible account of our research, made possible as it has been by career-long public and/or private funding.[11] This prescription applies, obviously, to historians of science as well. But with one extra consideration: vast audiences crave it. So many popularizing works annually see the light of day, often written by somewhat ill-prepared and/or carelessly working journalists, about famous characters and spectacular events in the history of science, and quite regularly such books attain bestseller status. Often, though luckily not always, these are books of the naïvely hero-worshipping kind. Profound is

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9 I could not remember where in Westfall’s writings I encountered this line, nor did I manage to find it back. But Jip van Besouw helpfully came up with the spot in question: Richard S. Westfall, ‘Newton and the Hermetic Tradition’. In: A.G. Debus (ed.), *Science, Medicine and Society in the Renaissance. Essays to Honor Walter Pagel*. London: Heinemann, 1972; 2 vols.; vol. 2, p. 183 – 198; the quoted passage is on 187.

10 In conversation at one time with the late Ed Grant I heard him use this term to characterize how his close colleague Westfall was in the habit of expressing himself.

11 I made the point in my *De ideale universiteit*. Amsterdam: Prometheus, 2020; p. 73.

the contempt in which historians of science hold such books. Ever since our predecessors have liberated us from the simple-minded hero-worshipping style of writing about past scientists, we have learned to conceive of history in another vein than that of a triumphal march from an already predetermined past toward the glorious present of our own time. As far as this elementary attainment goes, it is of course quite right that in professional circles this predominantly journalistic genre is regularly being scoffed at. Only, far too often has in these same circles the idea of first-rate science being something inherently worthy of admiration been a little too drastically deconstructed. Take a book already mentioned in another connection – *Never at Rest*. Here is what Westfall wrote in the book's opening lines about the man to the investigation of whose life and works he dedicated a very substantial portion of his career:

> The more I studied him, the more Newton has receded from me. It has been my privilege at various times to know a number of brilliant men, men whom I acknowledge without hesitation to be my intellectual superiors. I have never, however, met one against whom I was unwilling to measure myself, so that it seemed reasonable to say that I was half as able as the person in question, or a third or a fourth, but in every case a finite fraction. The end result of my study of Newton has served to convince me that with him there is no measure. He has become for me wholly other, one of the tiny handful of supreme geniuses who have shaped the categories of the human intellect, a man not finally reducible to the criteria by which we comprehend our fellow beings.

It is, alas, characteristic of an attitude met too often in the discipline that this very passage has been condemned by many a commentator as a prime example of the naïve hero worship we should meanwhile have learned to rise above. But does the, in principle, welcome refinement of our hero-worshipping sentiments really bring with it a need to ridicule any notion that the human capacity to arrive at some measure of understanding of the world around us might be something special, something quite out of the ordinary even? The public at large at any rate has no stomach for that particular kind of ultra-sophistication. Ordinary people are on the lookout all the time for people they can genuinely admire, that is, for heroes, for fellow-people who, for all their human flaws, have accomplished truly admirable things, be it in politics or in music or in literature or in science, and it is for good reason that most people love to read about such persons. If historians of science forsake the task of providing the public with responsibly narrated stories about great scientists of the past, in a spirit indeed of 'responsible heroism', then the public is perfectly prepared to go and find those stories elsewhere, leaving it to us in our professional corners to mutter indignantly about the next specimen of cheap journalism.[12] Luckily, numerous commendable examples are around of writing about past scientists in a vein of responsible heroism. A recent example, which combines the virtues of a professionally fully responsible handling of the lives in science of an in many ways admirable married couple with the flair and the sharp observations of a dyed-in-the-wool journalist is a dual biography of Paul Ehrenfest and Tatiana Ehrenfest-Afanasheva by Margriet van der Heijden. Born in 1964, she is a science journalist with a PhD in particle physics who, while at work on the biography, had no difficulty picking up in just a few years all one needs to write history of science the way the professionals do, only a lot more accessibly so than most.[13]

One category of language use that deserves some special attention here is *concepts*. Historians, and therefore historians of science as well, are not, as a rule, particularly adept at creating, let alone handling in a consistent manner, conceptual frames designed for purposes of analytical clarification. One major, and overall quite good, reason for us historians to keep our concepts somewhat fuzzy is that our core business is to seek to understand modes of change over time. Concepts, like everything else, do change over time – even what we habitually place in the oh so familiar-looking category of 'science' has hardly remained the same from one period to the next, to the point where for times before, say, Newton's *Principia* it is far better to avoid even the term 'science' itself and use 'natural philosophy' or, even better (because it is more ideologically neutral), 'nature-knowledge'.[14]

There are three ways in which working with sharply delineated concepts may lead the historian astray. It does so when, in a presentist vein, we take a current concept and project backward what it stands for today. It does so, too, when we adopt a concept from how some past character (say, Newton, or Darwin) arrived at it and went on to handle it, and then treat it as if it were bound to remain unaltered over its future unfolding. It finally does so

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12 A plea for 'responsible heroism' finds a place in an article 'Trots op 'onze' natuurwetenschap?' that I wrote in the journal *Opinio* in February, 2008.

13 I reviewed the book on https://www.shellsandpebbles.com/2021/10/05/voorbeeldige-dubbelbiografie/.

14 In my *How Modern Science Came Into the World. Four Civilizations, One 17th Century Breakthrough*. Amsterdam UP, 2010 I have opted for 'modes of nature-knowledge' as my unit of historical analysis; on p. xxviii I explain why.

when, in obediently going along with the still fashionable admonition that we should scrupulously stick to ‘actors’ categories’, we in effect ignore or even deny any conceptual concatenation over time – as if there were no links of meaning at all between, say, Michael Faraday’s concept of field and the modern concept. In each of these three cases we seek to fixate things where, in the reality of the past, fluidity reigns supreme.

To come up, in short, with some sharply-cut concept and then stick to what it is meant to stand for from one period to the next obscures rather than enlightens the very understanding of modes of change over time that, at bottom, we are after. To that extent historians quite wisely refrain from conceptual clarity in the sense so customary in most other disciplines. But that is not really all there is to the issue. The same, overall functional attitude toward concept formation just sketched may land us in difficulties – difficulties where help from outside may be indispensable. By this I mean help from scholars working in disciplines not directed in the first place at the interpretation and analysis of by definition unrepeatable events but rather at phenomena that, in displaying certain observable regularities, lend themselves better to generalization. If scholars of such a bent possess in addition some historical sense of their own, they can work wonders, or rather, they would, if only historians were prepared to listen to what they have to tell us.[15]

One case in point is a path-breaking book from 1971, *The Scientist’s Role in Society*, by the historical sociologist Joseph Ben-David (1920 - 1986). In its early chapters he analyzes certain social conditions, present for the first time in mid-17th century Europe, that were co-instrumental, so he argued, in making possible the onset of modern science. I have shown elsewhere how three “powerful unifying concepts” enabled Ben-David to make two impossibly broad themes often invoked by historians as causal agents, ‘the Reformation’ and ‘Europe’s dynamism’, finally do viable explanatory work. Reviewers were inclined to see in Ben-David’s way of handling the issue nothing but a rehash of familiar themes; they failed to see how these two themes were now made causally productive in a much more fruitful manner than before, bound together in their turn by the broad sociological concept of legitimacy – in this case, of freshly emerging science as a professional and, to some extent, autonomous undertaking.[16]

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15 Both examples that follow are taken from a lecture ‘ Can Historians Think In The Abstract?’ that I gave on 11 May, 1999 (the pdf is on my website www.hfcohen.com under ‘Shorter writings’).

16 *The Scientific Revolution*, p. 367 – 372, but see also p. 374. Much of what I learned from Ben-David’s book later found a place in *How Modern Science Came Into the World*.

Another, much more recent and this time career-long example is provided by the physicist, philosopher of science, cognitive scientist, and historian of science Nancy Nersessian. From the very day onward when she turned from physics to philosophy it has been her outspoken ambition to find out 'how scientists think'. Zooming in ever more closely, she has in her work provided razor-sharp analyses, developed always in ongoing dialogue with the empirical material she found or helped create herself, of broad concepts like 'thinking analogically', or 'modeling', that are usually handled with much vagueness and ambiguity.[17] Amidst all her history-infused efforts to make core concepts like these do work in ways that may satisfy both the philosopher and the historian, she once addressed a case where she found historians of science to have got stuck in the professionally so often functional fuzziness of the concepts they were working with. The concept in question was that of 'field', and the historians who got in trouble over it (without any apparent awareness of their trouble) were four modern authors immersed each in the work of Michael Faraday. All four were serious historians in the non-triumphalist vein, seriously concerned not so much with finding out whether Faraday 'already' had *the* modern concept of 'field', but rather with determining at what point in his electro-magnetic researches he had *his* concept of field. Striking about their respective determinations was that these came out radically different, with a time difference of no less than two decades in Faraday's most productive period of experimentation and theoretical speculation, and with quite different apparent criteria for what that concept actually was. It was at this point that Nersessian came to the rescue, and here is how she summed up her resolution of the quandary:

> First of all, the question of 'when' Faraday had his field concept requires that we say 'what' it is. This, however, involves three questions: What is a 'concept'?; What is a 'field' concept? and What is Faraday's 'field' concept? I have argued that a 'dynamic' view of a 'concept' fits the scientific situation better than the generally assumed 'classical' view [which involves a timeless set of necessary and sufficient conditions] and fits better with an 'historical/developmental' conception of meaning. Finally, I have attempted to supply answers for 'when' and 'what'

[17] The development of Nancy J. Nersessian's thought can be followed in her three books: *Faraday to Einstein: Constructing Meaning in Scientific Theories*. Kluwer, 1984; *Creating Scientific Concepts*. MIT Press, 2008; *Interdisciplinarity in the Making: Models and Methods in Frontier Science*. MIT Press, 2022.

> in the Faraday case. Of course, this has not been done on the basis of the new conception of 'concept' alone. It just allows us more flexibility in interpreting the historical data. With it we can (1) attribute a 'field' concept to Faraday quite early, without having either to attribute the whole thing to him or the modern conception to him; (2) claim that its specific features developed over time, in conjunction with further experimentation and 'speculation'; (3) say that it has some features quite unlike other field concepts and (4) still maintain that it is connected with other field concepts, in particular with the modern conception.[18]

So what we have here is a philosopher helping out the historian irretrievably yet unwittingly entangled in a deeply unhistorical idea of what it means to 'have' a scientific concept; that is to say, with basic issues, *and* their practical implications, in understanding the advance of science over time. I do not quite understand why so few historians seem to pay attention.

Not that sociological or philosophical clarification is the only manner in which conceptual clarity can become a boon to historical scholarship. A recent example of a very different way in which conceptual refinement may benefit historical scholarship are two books by Rens Bod (born in 1965). Educated as a linguist, his first plunge in the study of the past resulted in *A New History of the Humanities* (2016), the next one in a book with for subtitle *The History of Knowledge* (2022).[19] Both books cover nothing less than *all* time periods and *all* civilizations about which pertinent data are at all available. And yet, neither book has been written as one of those deadly boring enumerations of endless arrays of past facts. Rather, both center on two clearly defined concepts: 'patterns' and 'principles', and the story line is in both cases how in civilizations all over the globe certain regular patterns were discovered in phenomena, then principles that appeared to govern those patterns, then how consideration of those principles led to the recognition of second-order patterns, and so on, layer for layer added over time until close to the present day. Without the handling, at the same time firm and supple, of the two core concepts that hold each of the two books together nothing even remotely like it would have been possible.

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18 Nancy J. Nersessian, ' Faraday's Field Concept'. In: D. Gooding & F.A.J.L. James (eds.), *Faraday Rediscovered: Essays on the Life and Work of Michael Faraday*. London: Macmillan, 1985; pp. 175-187. (NB in conformity with her later insights, in the passage I quote in the main text the adjective 'dynamic' replaces the 'probabilistic' in her original publication).

19 Rens Bod, *A New History of the Humanities: The Search for Principles and Patterns from Antiquity to the Present.* Oxford UP, 2013 (in Dutch first: 2010); *World of Patterns. A Global History of Knowledge*. Johns Hopkins UP, 2022 (in Dutch first: 2019).

In short: for a historian of science it amply pays to take the plurilingual quality of the history of science into account; to write in ways that keep the audience, whether professional or of wider scope, alert to what you have to say; by all means to think at least thrice about how to handle in a historically responsible but also consistent manner what concepts your argument appears to require.

Panel (3): Facts & reasoning

The third panel of my polyptych concerns not just historians of science but really every scholar. It is about how in our everyday practice we deal with our factual material and how we reason about it.

Facts first. A good short-cut through a maze of pertinent issues, from fact fabrication, through sloppiness of all kinds, to handling our facts in more proper ways is to come up right away with the, for me, ideal example. It concerns a manuscript that Newton wrote in the late 1670s, as almost always undated and for himself alone, with for title *De aere et aethere* ('On air and aether'). In his 1971 book *Force in Newton's Physics* Westfall presented the first chapter of that treatise as a landmark on Newton's convoluted pathway from sheer particle mechanisms to forces of attraction and repulsion between particles. However, so the argument continues, what Newton states about air in the first chapter he seems to take back in the second, where he begins to discuss the capacity of air to be divided into subtle particles customarily called 'aether'. Newton even seems to suggest an empirically demonstrable capacity of that aether to let itself be divided in its turn into even subtler particles. Having come thus far in Westfall's rendition of Newton's argument, we read:

> And at this point, not yet at the bottom of the page and in the middle of a sentence, the treatise stopped.
>
> Who can say why Newton stopped? Perhaps he was called away to dinner, accompanied friends to a tavern for the evening, and lost the impulse to continue before he saw the paper again. It is also possible – and I propose it as a possible interpretation – that the tensions developing in Newton's philosophy of nature now reached the breaking point. ... Above all, *De aere et aethere* seemed to have embarked on an infinite regress. If the aether were, as he asserted, an elastic fluid like air, and if the elasticity of

> air were due to the mutual repulsion of its particles, what would he gain by referring the repulsion of aerial particles to the aether?[20]

What has impressed me so about this passage is that, even before Westfall begins to explain how his own interpretation of what goes on in Newton's treatise fits in with his (in 1971) highly innovative view of Newton's pathway toward forces as independent agents, he made it clear in the most concretely tangible manner possible ('dinner', 'a tavern') that his is just an interpretation, and as such a possibly erroneous one, *not* a certainty. More than a little hinged for Westfall on the historical tenability of his supposition of Newton sensing to have steered himself to the immediate vicinity of an infinite regress. Precisely this makes it so admirable that, even before confronting the reader with the full weight of his arguments in favor of that supposition, Westfall lays his cards open on the table – look, quite something else may have been the case!

Nor is this, in Westfall's work, a one-time-only remark. I know of no other historian of science who was so routinely out to mark the limitations to which his own interpretation of a given passage or situation is inevitably subject. In a footnote appended to the same passage he brings up the controversial matter of how to *date* the treatise:

> The thrust of my argument on Newton holds that he started with aethereal mechanisms – the commonplace orthodoxy of the day – and that he ultimately dispensed with them and replaced them by forces. [An earlier scholar has dated the treatise earlier than Westfall does, but] the development as I see it places *De aere et aethere* after the letter to Boyle. I recognise the danger of making one's own interpretation a procrustean bed to which the pieces of evidence are fitted by brute force. No point can be served by defending my interpretation in this note. It is spread through the text, and I can only leave it to the judgment of the reader.[21]

If only every historian of science, myself definitely included, were so habitually open about how far, in defending an interpretation, we may reasonably push our claims for its tenability! Westfall's line about interpretations and procrustean beds, in particular, deserves to hang on the walls of every academic building. Not that we academics are unaware, deep down, of its truth – it is only that we need to be reminded of it all the time.

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20 Richard S. Westfall, *Force in Newton's Physics*, p. 374-375.

21 *Ibidem*, p. 409-410.

In the same vein, but now in a somewhat broader sense, Westfall could also be counted on to supply an interpretation of his, especially if it was a boldly innovative one, with all the evidence he could advance in its favor without letting it elucidate more than what the evidence could still reasonably be taken to bear. He was even in the habit of listing whatever evidence he was aware of that seemed to speak *against* an interpretion of his, followed by a carefully balanced discussion of the pro's and con's of the evidence taken as a whole. For all the pithy phrasing and, on occasion, deliberate rhetorical overstatement Westfall excelled in as well, his *oeuvre* is perfused by an enviable sense of proportion. [22]

Further examples of that sense of proportion in action could of course be given, but what I have said so far suffices to state the moral of this particular story: keep your human capacity to err in mind all the time and be open about it; don't blow your findings up out of proportion to the net amount of evidence that you have managed to establish for it.

So much for how, in interpreting our facts, to deal with them; now for how to reason on the basis of facts and interpretations alike. For historians something of a textbook on the subject has been available for over half a century (soon after it came out in 1970 my thesis supervisor called my attention to the book). It is David Hackett Fischer's *Historians' Fallacies. Toward a Logic of Historical Thought*. In 318 lively pages Fischer lists a vast quantity of ways in which historians may go, and have gone, wrong in their reasoning, with examples (at times rather painful ones) given for every single fallacy. I still think that no historian who cares for sound reasoning should leave the book unread. Nonetheless, the book is stronger in recommending what to avoid than in explaining how to do it better.[23] What may come to the rescue here is the chapter 'Rationality' in a so far unpublished book by a social scientist, the late Rob Wentholt. His book is entitled 'The Nature of Human Nature', and this particular chapter offers a deeply digging analysis of the ways in which key elements of our human make-up may cause our reasoning oh so easily to go off the rails of what our cognitive capacity is made for – to attain a reliable grip on this or that

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22 Unfortunately, Westfall's careful balancing of the evidence has been mistaken by one historian (Mordechai Feingold) for *lack* of evidence (see my essay review 'Stock and bulk in the latest Newton scholarship' in the December 2018 issue of the *British Journal for History of Science* 51, 4; p. 687–701; in particular p. 697-698).

23 Even so, I have derived the insight employed earlier in the text about the core business of historians residing in an unceasing effort to come to grips with the what, the how, and the why of change over time straight from Fischer's book (p. 315).

aspect of reality. I confine myself to what in Wentholt's view constitutes perhaps the most pervasive and also the most treacherous of the manifold ways in which we are prone to misuse our human capacity for rational thought. This is the either/or fallacy.

Why call that fallacy pervasive, and why call it treacherous? I give an example first – in this particular case an inevitably negative one. It concerns an in itself admirably coherent collection of papers that came out in 2012 under the title *The Identity of the History of Science and Medicine*.[24] The author, Andrew Cunningham, distinguishes himself from the majority of historians in his care for conceptual clarity and consistency. The themes he addresses vary widely, from Newton's *Principia* to the plague, but the message is always the same. In each case, so he argues and keeps arguing, we may notice a dividing line which makes the subject under scrutiny radically different before and after. Living as we historians do at the more recent side of this or that dividing line, if we cross it backward we tend to get our history writing just plain wrong. When, for instance, we believe that prior to the age of the laboratory we see some medical doctor diagnose the plague, we are wrong – our very concept of the plague has irrevocably been determined, *redefined* even, by a range of bacteriological tests inconceivable before the invention of those very tests. Therefore, when we commiserate with pre-modern doctors who sought in vain to get hold of what caused those terrible outbreaks of the bubonic plague, we are mistaken – that pre-modern doctor was addressing something other than we do. Just so, when we believe that prior to the 19th century we see science, we really see natural philosophy – something else entirely, in that it includes, as 'science' has never done, revelation of God's handiwork as the primary aim of every investigation. Therefore, so Cunningham concludes in view of the circumstance that in England considerations about God were part of many an investigation until about mid-19th century, the *real* Scientific Revolution did not take place in the 17th century but some 250 to 150 years later.[25]

[24] I take the account of Cunningham's book that follows from my review 'Dichotomous conceptualization in the history of science' in 2013 in vol. 22 of the journal *Metascience*.

[25] Even for the period of the (in Cunningham's view, non-existent) Scientific Revolution his argument breaks down on elementary facts like the circumstance that, for instance, Pascal or Huygens left God completely out of their scientific concerns (Pascal for explicit methodological reasons; Huygens for lack of belief in more than a Stoic kind of godhead; more on this in my as yet unpublished book 'Unsettling Knowledge' (published in Dutch in 2016 under the title *Het knagende weten*).

In Cunningham' s outspoken view, then, historians of science come in two kinds only – those very numerous ones who failed or still fail to be aware of these dividing lines and who, therefore, naively project their present-day conceptions back upon earlier times, and those who at some point in their education as historians of science *have* become aware of them. The latter are Cunningham himself and a few more, likewise "Leftist" members of his peer group – these happy few broke with all previous history writing and came up with a brand-new approach. What I sketch here is hardly a caricature of Cunningham's apparent views, although it definitely *is* a caricature of what really happened in the writing of the history of science. For if that history is marked by anything at all, it is by an ongoing effort, starting in the 1920s at the latest, at historization in the sense of an awareness that *their* concepts (those of Aristotle, or of Galileo, or of Darwin ...) were not, or not entirely, *and certainly not unproblematically*, *our* concepts. We already addressed the matter in the previous section. Historization is an ongoing business – it is the one feature that holds the discipline together. When, to mention just one instance, in 1924 E.J. Dijksterhuis unraveled the essentially circular nature of Galileo's concept of motion retained, he in that very act historicized what earlier commentators had taken to be just the modern, Newtonian, rectilinear concept of inertia. Dijksterhuis did not have to wait for Cunningham and his peer group to tell him so – this is what he found out for himself, as near-contemporaneous historians of science like Alexandre Koyré or R. Hooykaas or Hélène Metzger began to do as well. Nor did Dijksterhuis conclude that Galileo, with his circular conception of motion retained, was dealing with something utterly different from, let alone incommensurable with, the modern concept of inertia – he remained very well aware, as many others in the business of historization were and are well aware, that these are historical *filiations*, not dichotomies. To be sure, when we now read the accounts of Dijksterhuis and his generation we find much in it that has meanwhile become obsolete, and also much that is still in need of further historization. But this is nothing but insisting that historization is an ongoing business, with one generation building forth upon its predecessor rather than making the clean break beloved by Cunningham on the strength of his compulsive either/or thinking.

Precisely this compulsiveness is my main point here. Surely there are, in life as well as in scholarship, occasions when we are facing a starkly binary choice. But it is one thing to recognize those relatively rare occasions for what they are, and quite another to succumb to the pervasive, also treacherous habit of either/or thinking.

Wentholt has placed this and two closely related thinking habits ('all or nothing'; '*pars pro toto*') in a category that he labeled 'cognitive grooves'. Surely personality traits and many other factors are involved as well; yet what makes 'either/or' thinking so pervasive in, notably, the cultures of Judaism, Christianity, and Islam is that they are perfused by the monotheism they have in common:

> As a shared cultural value and a general frame of mind, the legacy of intolerance of everything that can be defined as sinful deviance from the correct path oozes from the very pores of traditionally monotheist cultures. ... The general cultural/personal consequences of this particular tradition of thinking are incisive. Let us concentrate on monist thought patterns. One god, one law, one right way, one reason, one cause, one explanation, one way to be – no complications, contradictions, incompatibilities, or complexities allowed. The monotheist tradition creates a frame of mind in which a 'simple and sovereign' Oneness of things as the desirable condition to aim at goes without saying; and everything which complicates it or seems to contradict it is seen as an obstacle to be removed.[26] ... It is one of the strongest legacies of monotheist religious dichotomies. ....
>
> The mental habit of either/or thinking does not need heavy motivational/emotional investments to come into its own. With just a little help from feelings of right and wrong and of pleasure or pain, the cognitive groove may be quite enough on its own strength. It is so easy to assume without any other motivational involvement than the pleasure of feeling grip that someone not entirely good is entirely bad, and vice versa. ...
>
> The only remedy against the compulsion of judging something as 'either this or that' is to cultivate and encourage as an alternative guiding principle a 'both this and that' approach. Instead of being either 'naturally good' or 'naturally bad,' people and ambivalent situations may more easily be thought of as a possible mixture of what is considered good and what is considered bad. However, this already presupposes a cognitive readiness to accept the potential complexity of things.
>
> The tendency to throw away the baby with the bathwater must at the same time be combated as well. There is always the danger of relativity absolu-

[26] Wentholt refers here to the expression 'simple and sovereign theories' coined by the social psychologist Gordon Allport.

> tized (itself an example of monist thinking). Once someone is converted to the idea that things cannot perhaps be explained quite so simply as he is wont to believe, he quickly tends to assume that there is no point in trying to find objective explanations for them at all. So the challenge is to convince him of two things at once: truth may not be simple, but truth must still out.[27]

Now for what, beside pervasive, makes the cognitive either/or groove so treacherous. We have already found the anwer in the very example of Andrew Cunningham's collected papers. Here is a very smart historian, motivated by a rare, overall quite wholesome awareness of the inclination of most historians to handle their concepts with undue sloppiness, and out to do it better. More than bright enough to rise above simple-minded either/or patterns of thought, he nonetheless adopts the cognitive groove as he swims along (like all of us do) in a still very much monotheism-pervaded culture. And now for what is really so treacherous about it: once he has set out on his first dichotomy, nothing appears to hold him back any more. The binary pattern is repeated without any apparent further reflection, and without an end anywhere in sight, to the very point where the entire discipline of the history of science, meanwhile comprising thousands of scholars for over a century, is split up into just two radically opposed parties – the party of himself and a few likewise Labour-voting friends who have likewise seen the light, and all the others. At this point Light and Dark, God and Devil are almost visibly looming in the background. This is the self-radicalization that cognitive grooves have in store for us, *all* of us, if we fail to watch out for them all the time, be it in others or, even harder to do, in ourselves.

Panel (4): A broad vision

With ideal portraits now sketched of sources & literature, of language & concepts, and of facts & reasoning, the time has come to broaden our vision. In the history of science 'a broad vision' may stand for many things, two of which seem particularly pertinent – broadening the range of subjects investigated, and broadening the variety of possible approaches. In practice, the two are not always easy to separate, but let us start with the latter variety anyway.

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27 Rob Wentholt, 'The Nature of Human Nature', ch. 15 'Rationality', section 'Non-rational thinking habits: performance sets, connotative labeling, intolerance of complexities' (se about this as yet unpublished book https://natureofhumannature.com/).

When the process of historization started in the 1910s/1920s, the history of science took shape almost exclusively as a history of scientific ideas, with 'scientific' often taken in an ample sense.[28] On occasion very substantial upheavals in the formation and alternation of at times very daring, often philosophical ideas about, say, free fall, or the ultimate constitution of matter, were until far into the 1970s regarded as the very backbone of the history of science. 'Internal' history of science was the main thing, all the while an 'external' approach made itself known by way of Marxist-inspired efforts to reduce ideas to their purported, socio-economic *Unterbau* (substructure). Past scientists' thoughts and the adventures of their thoughts over time, then, were what the discipline at bottom was about. The man who after the Second World War came widely to be seen as the very embodiment of this approach was a Russia-born Frenchman by the name of Alexandre Koyré (1892 – 1965). He demonstrated in an exemplary manner how the history of scientific ideas could be cultivated without being affected any longer by the positivist overtones that still marked the work of many of his contemporaries, George Sarton in the first place.

Since the days of Sarton and Koyré the discipline has broadened itself in several ways and in several directions. The initiative was taken in each case in the Anglosaxon world of scholarship; in each case wider societal transformations could easily be perceived at the background. To give a place of its own, in the history of how science came about, to magic-perfused currents of thought in pre-modern times: here the British historian of ideas Frances Yates was the pioneer who, with her 1964 book *Giordano Bruno and the Hermetic Tradition*, attained prominence and, to her considerable surprise, acquired numerous adherents about a decade later. To set right the often underestimated or more or less willfully ignored contributions of women to science at every level, in the past as well as in a present found less and less acceptable: here Evelyn Fox Keller, Margaret Rossiter, and Rima Apple took the initiative in the 1970s/1980s, with Carolyn Merchant's book of 1980, *The Death of Nature: Women, Ecology, and the Scientific Revolution* serving as the most visible signpost of the new movement.[29] To enrich the by and large 'pure' history of scientific ideas in the style of Koyré with deep interest in the local situatedness of those ideas

[28] There were, of course, exceptions, as for example with R. Hooykaas' early interest in the role of the arts and crafts in scientific advance (more on this further down in the same section).

[29] Sally Gregory Kohlstedt, 'Women in the History of Science: An Ambiguous Place'. *Osiris* 10; 1995; pp. 39-58.

and of their material embodiment in instruments and experiments: here Steven Shapin & Simon Schaffer fired the opening shot in 1985 with their widely and immediately appealing *Leviathan and the Airpump*.

Not that the broadening of the overall view of history hugely stimulated by these three innovative initiatives took place by way of a gradual process. It never happens that way. Indeed, to suppose that it would have happened that way is rather to underestimate what, not just in the history of science but in the humanities and the social sciences overall, rather constitutes the standard pattern, which can be summed up in three words: fashion reigns supreme. A few pioneers start a movement of sorts, and a bandwagon effect follows (or fails to follow; this is the unpredictable element in the cycle). One practitioner after another jumps on board and, be it from inner conviction or from a sense that this is where the wind is now blowing, begins to produce work in broad accordance with the new rules, now ornated with the self-congratulatory term 'turn' (for instance, 'the material turn'). The net long-term effect, to be sure, is most often salutary, in that productive pathways toward potentially quite significant results have now been opened that did not exist before, or in the margin at best. As a long-term result the discipline's collective vision has been broadened indeed. In the case of the history of science, broadening takes shape as ongoing historization in the sense discussed above. That is to say, segments of the past of which it has so far been taken for granted that they have always been more or less what they are at present, begin to look significantly different if now considered as they were then, not as they look now.

For all the net benefits that such a new wave of historization appears to bring in the end, there are also considerable and, from an intellectual point of view, quite needless losses. This has everything to do with the cognitive fallacy discussed above: that hard-to-resist urge to split issues at hand up in polar opposites. Of the three 'broader vision' innovations listed above, the third one in particular, directed as it was at investigating the local situatedness of some given case of science-in-the-making and the material embodiment thereof, came right from the start packed in a radical 'either/or' dichotomy about the nature of the scientific enterprise itself. Overall persuasive demonstration that it might well pay off to give proper attention to how exactly scientific ideas and practices came up in a wider setting of local, socio-economic, and cultural context went in tandem with the view that locality is all there is to science – no claim of universal validity could be accepted for science any more. Even more than that, the new approach was presented as a resolute partisan stance in favor of a denial of (or at the very least a studied neglect to take into account) the capacity of science to inform us reliably about vital aspects of the real world. In its most radical guise, relativists maintained that scientists do not inform us at all about the true constitution of the natural world or any part of it, but only about the outcome of the ongoing negotiations, conducted and fought out in their labs on an everyday basis, about what deserves henceforth to be called 'nature'. The relativist stance vis-à-vis science and what it stands for was at the heart of the so-called Science Wars that had just broken out in the USA. Every historian of science was now invited, as it were, to take sides in that either/or debate. In such a climate of polar opposition partisan mythologies may easily arise, and so it went in the 1980s, too. It is a core tenet still widely held across the discipline four decades later that historization started in the mid-1980s – all that went before came allegedly down to expressions of sheer old-fashioned, positivist triumphalism. As one major consequence, work from before the mid-1980s (or written later but with so-called 'old-fashioned' history of scientific ideas at the center) could, and can, safely be ignored.

These days another fashion is quite visibly in the making, with (thanks to the internet) an even more immediate bandwagon effect. There is no need to dwell on this any further (or on the phenomenon itself of scholarly advance by way of one fashion succeeding another)[30] – an exemplary countercase may serve quite as well. Robert S. Westman (born 1941) has over his entire career dealt with, and benefited greatly from, the widening that has taken place in the history of science since the mid-1970s, without ever jumping on any bandwagon. A non-demonstrative yet quite remarkable insensitivity to fashion in any guise or disguise has been a hallmark of his work, and this without ignoring either the presence or the potentially fertile inner core thereof. Rather to the contrary, Westman has taken care to subject both the 'Hermetic' and the 'local situatedness' current to careful scrutiny and evaluation with a view to finding out where they may lead to deeper insight and where they tend to go beyond the limits of what is still empirically tenable. A comparison of his 2011 book *The Copernican Question. Prognostication, Skepticism, and Celestial Order* with his early writ-

30 For somewhat ampler treatment I refer to a chapter 'Science and History in the History of Science'that I contributed to *The Routledge History of American Science* (forthcoming).

ings from the mid-1970s quickly reveals the significant extent to which he has managed to incorporate in that book approaches and conclusions that have come in sight for him due to these two innovations – all this without ever going along with the binary partisanship that originally came with them and that still lives on subterraneously with the 'local situatedness' vision. It testifies to how obdurate the sense of partisanship has proven to be that critics took Westman's book as fitting in seamlessly with the 'history of ideas' tradition. Thus they missed how, for instance, Westman handled the 15th and 16th century astrological treatises that were key to one major tenet of his book, not as texts expressing certain ideas only, but in at least equal measure as documents head over heels involved in the power struggles of princely patrons.

The other main type of broadening is not so much about approaches as, rather, about subjects. Few if any historians of science can compete in sheer breadth with R. Hooykaas (1906 – 1994). Remarkable about the classes he taught his students (I was one of them) was not that he covered in two years the entire history of science; remarkable, not to say unique, was rather that, without leaving out anything of principal importance, in his teaching he reproduced sources-based researches undertaken by himself of every single subject that came up as he moved on in his weekly classes 'from Babylon to Bohr' (to cite the title of the book in Dutch that he published in 1971). Historians of early Portuguese navigation over the Atlantic and the Indian Oceans recognized Hooykaas as a fellow-expert with a contribution of his own about the drastic consequences of the Voyages of Discovery for Portuguese views on natural philosophy and on how best to make, and check, systematic observations. Just so, scholars with expertise in the history of the relations between science and religion who were familiar with his numerous publications on the subject took his views with the utmost seriousness. Later historians of geology recognized him as the pioneer. Ditto in the history of crystallography. And so on, and so forth. Beside significant topics in these domains he published (to select a few more topics) on the extent to which Lavoisier remained forever indebted to the phlogiston account of combustion; on Pascal's science and his religion; on his beloved theme of 'thinking with the hands' (in works by Pierre de la Ramée, by João de Castro, by René Just Haüy, and by many others); on certain Dutch alchemists; on medieval thought experiments about a stone supposedly falling down a tunnel through the Earth, or on the idea of harmony in nature in Kepler's work, in the Law of Titius-Bode, in Richter's laws of acids and bases, in Newland's law of octaves, or in ‘the harmony of light: Balmer to Bohr’. The last-mentioned phrase is the title of a chapter section in Hooykaas’ posthumous book *Fact, Faith and Fiction in the Development of Science* (1999). This book not only reflects the huge variety of Hooykaas’ expert interests, it also reveals the three interlocking themes that lent all these varied studies their underlying coherence. One of the book’s editors summed up Hooykaas’ basic views about the history of science thus:

> Science in its ongoing advance ... never ceases to display quite variously mingled contributions from *faith* [not meant here in a religious sense but standing rather for broad, *a priori* held ideas like unity, or simplicity, or harmony], from *facts* (given by nature yet entirely subject to our mode of interpreting them), and from *fictions* in the sense of those daring intellectual tools, such as theories and hypotheses and models, which reflect the scientist’s creative imagination.[31]

It was this broad conception in particular that gave needed depth to the vastness of Hooykaas’ invariably sources-based explorations over the length and breadth of the history of science.

Breadth of vision may also stand expressed in some comprehensive research question and how the investigator deals with it. An outstanding example is a 1,989 pages long *tour de force* by an Australian historian of science, Stephen Gaukroger (born in 1950). He wanted to know how it is “that science, utterly marginal in Europe’s medieval culture, has become central to our modern culture.” In the Middle Ages science stood in the outer margin of almost everybody’s interest or sphere of activity; today science stands, be it more or less visibly so, at the very center of our everyday concerns; how has this fundamental change come about? Gaukroger’s deservedly multiform yet far from vague answer or rather range of answers to this question of almost deceptive simplicity took shape in a sequence of four tightly coherent volumes that came out between 2006 and 2020 with for shared subtitle ‘Science and the Shaping of Modernity’. In a way, these four volumes step into the void brought about by the well-deserved demise of overviews of the history of science that used to offer a poorly organized range of major and more minor scientific discoveries, held together by a positivist or even triumphalist sense of inexorable progress – as if the cen-

[31] R. Hooykaas, *Fact, Faith and Fiction in the Development of Science. The Gifford Lectures Given in the University of St. Andrews 1976*. Dordrecht, Kluwer: 1999.

trality that science has attained in our modern thinking and way of life has been the self-evident consequence of its unmistakeable truth-value. To ask the question anew without any tinge of such presentism is what Gaukroger set out to accomplish. Key to the endeavor has been his acute awareness that we must distinguish between science as an enterprise directed toward coming to grips with the natural world (and, at later stages, with our social world and with our inner selves as well), and science as an enterprise in need, like any viable enterprise, of consolidation in order to flourish or even to survive. Throughout the series Gaukroger stuck to his own declaration of independence of all pre-set methods or approaches, preferring to select or develop his own organizing concepts as he went along.[32]

By way of a moral to the story in this particular section, I give the floor to an in his own time very well known Cambridge erudite, William Whewell:

> This is the spirit in which the pursuit of knowledge is generally carried on with success: those men [but of course women as well. HFC] arrive at truth who eagerly endeavour to connect remote points of their knowledge, not those who stop cautiously at each point till something compels them to go beyond it.[33]

Panel (5): Daring

Not by chance, the paragraph by Whewell that closes with the passage just quoted, opens with this one:

> ... advances in knowledge are not commonly made without the previous exercise of some boldness and license in guessing.

Indeed, from the theme 'breadth of vision' to the next and final theme 'daring' is but a relatively small step. One example of unmistakeable daring is to be found in the scholarly work of Lawrence Principe (born 1962). It was one thing for Hooykaas and a few others in the early 1930s to recognize the capacity of at least some authors of alchemical treatises to rise above the level of irrational fiction, and to go ahead and make a serious effort to decipher their often complex and esoteric language and imagery. In the

[32] I have taken some phrasing from my essay review of the entire series: *Isis* 112, 1: March, 2021.

[33] As quoted in my *The Scientific Revolution*; p. 29 (referred to William Whewell, *History of the Inductive Sciences*, vol. I; p. 318; p. 326).

1970s, with the 'Hermeticist' wave of innovation, the taint of the irrational began to wear off, and more investigators followed suit. Even so it was still quite something else for Principe to go ahead at the very start of his career as a historian and (against much opposition at first) to take descriptions of alchemical experiments to the lab in the chemistry department of his university in an effort to replicate them, with at times very spectacular outcomes. Once again historization took a big step foward. As he moved on he began, together with William Newman, to make the case that for the period investigated (the 17th century mostly) there really are no tenable criteria for making a clear-cut distinction between alchemy and chemistry, so that it makes better historical sense to conceive of the compound as one whole best called by its contemporary name 'chymistry'. As he kept investigating chymical treatises and the practices described therein, Principe further found that practitioners of gold-making chymistry went on at least half a century longer than ever imagined by those (that is, by everyone) who had taken it for granted that with the first stirrings of the Enlightenment alchemy would have come to a well-deserved end.

Another example takes us to another lab in a farther past, the Cambridge biochemistry lab in the year 1937. Three Chinese students have a question for their professor (locally known for his deep interest in history). How is it, they want to know, that modern science originated only in Europe? Rather than taking the question as a dinner-table topic good for an evening of flimsy speculation, the biochemistry professor, by the name of Joseph Needham, is captivated for good. Forever interpreting the question as "Why not in China?", he sets out to learn Chinese.

Only a few years later, in the middle of the Second World War, the professor grabs a chance to join a mission to China, and plunges himself head-on into the history of Chinese science – a subject that, as the then current wisdom of Confucian literati has it, does not exist. In 1944, on an isolated spot in Yunnan province, he begins to entrust to paper his first thoughts on the subject, offering some preliminary, tentative answers to the question originally put before him by those inquisitive students. He has meanwhile come to the conviction that the question is "one of the greatest problems in the history of civilisation". He also thinks that one book – already vaguely conceived in 1938 but to be written by him after the war ends – would answer it.[34]

[34] For the phrasing of this and the next paragraph I have used p. 418-419 of *The Scientific Revolution,* and the opening paragraph of an 'Editorial Introduction' I wrote in *Isis* 110, 1; March 2019.

Ten years later again, in 1954, the first volume appeared of *Science and Civilisation in China*. Needham had in the meantime expanded the project to cover seven volumes, organized so as to come up, in the final volume, with what would constitute his definitive answer. The plan for the overall content (left basically unaltered ever since) foresaw a division of these seven Volumes in 50 Sections altogether. At first, the rate went at a Volume a tome, each Volume covering a number of Sections. In the 1960s Volumes began to be split up in Parts, and soon after just one Section succeeded in filling several tomes all by itself. As he went along, research and writing turned into an ever more collaborative effort, with Needham and his singular vision always at the center. At the same time he oversaw the writing (by Colin A. Ronan) of 5 volumes of *The Shorter Science and Civilisation in China*. Needham died in 1995 at the age of 95, but publication (always with Cambridge University Press) went on. Today, in 2022, twenty-five lavishly produced tomes have appeared of *Science and Civilisation in China* (two tomes still stand out to complete the series). Indeed, rarely in the history of 20th century scholarship has such an innocent question yielded such impressive results!

What, meanwhile, about the original question that, in 1937, caused Needham to set out on his quest? Lynn White, Jr., a historian of technology likewise fascinated by big historical issues, dubbed it 'Needham's Grand Question', and the number of people who took it up to deny its validity or, to the contrary, to come up with some commonplace and/or light-hearted answer of their own runs in the dozens. Needham's own answers came forward, not in the series itself but in several accompanying essays.[35] A sustained analysis thereof proved revealing in more than one respect. From one essay to the next Needham varied the precise formulation of his Grand Question, sometimes substantially so and with effects enduring in many a later essay. Answers that he came up with display much diversity, leaving it unclear how he saw their mutual relationship but also what status he ascribed to every single one, and even whether he regarded one, or two, or even more of the net six identifiable answers as finally decisive. More than once he grounded an argument in favor of some proposed answer in interpretations that are in effect much radicalized versions of far more moderate considerations developed in the pertinent volume of *Science and*

[35] I have analyzed Needham's Grand Question and the five plus one answers given, four answers rejected, and one answer avoided by him, plus how these answers are mutually related in his work, in my *The Scientific Revolution*; p. 420–471.

Civilisation in China. His answers were further pervaded by ideological bias of several kinds, notably his political preferences (Marxist with mildly Communist overtones); his 'organic' view of proper scientific knowledge; his preconceptions about how modern science came about in Europe, and, above all, his touching yet at times quite uncritical love affair with the civilization of ancient China. All of which comes down to saying that, all the while digging deeply in thousands of its documents, Needham fell head over heels in just about every methodological trap that lies in waiting for whoever gets engaged in large-scale cross-cultural comparison (indeed, it is to Aydın Saylı's great credit that, when in 1960 he compared the rise of science in Europe with the fate of science in Islam civilization several centuries earlier, he managed so skillfully to avoid them all).

All these major reservations may be well-deserved, and yet, this is hardly the main point at issue here. For does not every pioneer risk falling in traps that, thanks to his or her example, later generations have learned to circumvent? No pioneering effort is flawlessly undertaken; someone must be the first, and the sheer circumstance that, in exploring untrodden territory, the pioneer has made all kinds of at times egregious mistakes is hardly sufficient reason to conclude that the entire venture has been in vain. Rather to the contrary, the very circumstance that, a quarter century after Needham died, the sum of our knowledge of all those efforts undertaken in pre-modern China to come to grips with the natural world, is due above all to this great man. In a sense, this conclusion was foreseen by Lynn White, who once remarked about Needham: "He is able to ask large questions because there is in him no trace of the vanity that quails at the prospect that someone may think his answers wrong."[36]

A fitting moral to draw from this section about daring might rest in four lines from a Revivalist hymn once quoted by George Orwell:[37]

> Dare to be a Daniel,
> Dare to stand alone,
> Dare to have a purpose firm,
> Dare to make it known.

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36 As quoted in *The Scientific Revolution;* p. 419; referred to L. White, Jr., *Medieval Religion and Technology. Collected Essays*. Berkeley: University of California Press, p. xviii.

37 In 'The Prevention of Literature'; according to https://libguides.unm.edu/c.php?g=951307&p=6965817 the hymn is by P.P. Bliss, who wrote it in 1873.

The polyptych whole: A complete, exemplary portrait

In the manner in which, in the preceding pages, I have been rendering panel themes, situations, events, developments, but also books, viewpoints, and more, I have striven for objectivity in the sense of an object-, not a subject-directed approach. For the choices I have made in *selecting* those themes, books, etc., it would be senseless to make a similar claim. There my personal preferences came first, tinged as they inevitably are by where my own central research question has led me over the decades. If not the problem of how modern science came into the world but some other historical question had sent me to spots quite unforeseen at the outset, I would have selected, not perhaps other themes for my five panels, but surely other work by other exemplary figures to illustrate them with.

The same reservation applies to where, in my personal view, the heart of the discipline of the history of science is located. I stand in awe of much that situating ideas in their variously social, economic, political and cultural contexts has brought the discipline, and from the 1980s onward substantial chunks in my own work go to show it.[38] Even so, it seems to me that, however much contextually enriched, the history of science remains in the first place a history of scientific ideas – very big and immensely fertile ideas like universal gravitation or plate tectonics or evolution by way of natural selection, but also smaller and (as a rule, but not always) mistaken ideas. Indeed, in the world history of ideas, scientific ideas are ideas at their most risky and their most acute. They are ideas in need of the most rigorous empirical checking but also ready-made to undergo the check and, who knows, survive it. It is this feature above all that turns scientific ideas into the very stuff that humanity has managed to acquire for arriving at some always partial understanding of what the world around us really is like. I personally know of no better way to sum up this conception of what the history of science in the end is about than in a phrase coined by Alexandre Koyré. The history of science, so he wrote in 1935, is the history of "l'esprit humain aux prises avec la réalité" ('the human mind struggling to grasp reality').[39]

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38 A programmatic summing-up is on p. xxxi - xxxii of *How Modern Science Came Into the World*.

39 Alexandre Koyré, *Etudes Galiléennes*. Paris (Hermann), 1939-1940 (ed. used: 1966); p. 11 (in the book's first paragraph).

A senior co-professional once told me that Alexandre Koyré served as the past figure whose (naturally imagined) posthumous nod of approval for his own latest publication would count for him uppermost. That senior co-professional was Richard S. Westfall. I, too, have a figure of posthumous approval constantly in mind, and it is (by now few readers will be surprised) Richard Westfall in his turn.

Westfall has already made an appearance in this essay on every panel but the two final ones. I singled out the exemplary way in which he handled his sources and the literature he consulted; I gave an example of his pungent writing style; I showed how he used to handle his facts and how careful and open he was about the sensitive issue of both the fallibility and the limits of our historical interpretations. I could in addition have given some details about his lack of sensitivity to fashion, and about his pioneering work on the theme of patronage that became popular later. But enough of that; it is about time to give Westfall his proper place on the two final panels.

First of all, Westfall hardly lacked daring. When in the 1970s he set out to investigate Newton's alchemical work and soon concluded that a great deal more was at stake there than a passing interest in alchemical treatises written by others, this finding by the man committed to writing Newton's biography caused rather an uproar. One of the most prominent and influential historians of science at the time, A. Rupert Hall, had written an entire book on the Scientific Revolution with for leading theme that that Revolution signified the emergence in 17th century Europe of rational thought about nature.[40] Considered in that perspective, it was one thing to take a handful of fairly obscure alchemists seriously, the way Hooykaas and a few others had already been practicing for decades. It was quite something else to argue that Sir Isaac, the very paragon of rational thought in Hall's view, would have deigned to have truck with the doctrine and the practice of alchemy to any greater extent than just taking passing notice of it. How deeply upset Hall was about what he felt to be at stake here, may be inferred from a comment he made at a conference held in 1974 on the isle of Capri, with the proceedings appearing one year later as *Reason, Experiment, and Mysticism in the Scientific Revolution*. The issue of rationality was taken up with particular cogency by Paolo Rossi (one of the protagonists of the 'Hermeticist' current now in the ascendancy), and by his commentator,

[40] I discussed Hall's (and his wife's) views on the Scientific Revolution in my book of that name, p. 114–121.

Rupert Hall. In his comment Hall phrased his problems with the approach in no uncertain terms:

> Rossi raises the issue quite simply – and he is right to do so: if the history of science is concerned with rational discourse between men, then the study of alternative models of discourse is certainly of auxiliary interest only; if on the other hand it is not (perhaps because of some special link between the 'pseudo-sciences' and the deepest levels of the human psyche, for example), then not only has the history of science as understood for the last three hundred years been a colossal fraud, but so has science itself.[41]

What makes Hall's statement so powerful a symptom of very deep-seated feelings about the issue at hand is that it came from the same man who, seventeen years earlier, had gone on record with the assertion "I dislike dichotomies; of two propositions, so often neither *a* nor *b* by itself can be wholly true."[42]

And now, by and large simultaneous with the Capri conference, another historian of rising prominence was prepared to go still a major step farther in that he claimed Newton's manuscripts, if carefully read, to leave no reasonable doubt about either his outspoken adherence to alchemy or his theoretical *and* experimental contributions to it. I remember little of the international congress on the history of science that, still fresh to the discipline, I had a chance to attend in Edinburgh in 1975, but two pictures still stand out in my mind. One was that, whatever any given speaker had just been talking about, a senior figure of imposing length who I soon learned to be Joseph Needham rose to inform us that something quite similar to what the speaker's main person had undertaken had been accomplished likewise by X – followed the name of some Chinese scholar (every time another name) no one in the audience had ever heard of. The other mental picture is of a speaker announced to be Richard S. Westfall, who made it quite clear from behind the rostrum that the contents of those Newton manuscripts just left him no choice and then, in his booming voice, rounded off his pertinent argument with a loudly exclaimed "*I* didn't write them!" The risk of being kicked into outer darkness by men with quite some say in the discipline did not hold him back when the textual evidence pointed so clearly in the direction he felt duty-bound to follow.

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41 As quoted in *The Scientific Revolution;* p. 179.
42 *Ibidem*.

And then there is the breadth of Westfall's vision and how he related that vision to the sources he was working with. As a lecture preserved on YouTube reminds us,[43] his central scholarly concern was the Scientific Revolution. A believing Christian himself ('I am a Presbyterian elder' was a line he hoped to shock the atheists among his younger friends with), he could not, in investigating Newton's numerous theological manuscripts, help noticing the absence, in Newton's mature views, of certain vital elements of traditional Christianity: "Nowhere did [Newton] approach the Bible as the revelation of truths above human reason unto life eternal."[44] All the while taking care to point out what was tradition-bound in Newton's theological views, Westfall saw radical novelty in some of his theological treatises, and he recognized it as Newton's own response to a subterranean current that Newton, like most other 17th century pioneers of modern science, was painfully and urgently aware of. Here is how Westfall phrased his principal thesis on the subject:

> Like Boyle, Newton was aware that the ground was shifting under the traditional foundations of Christianity. *The central thrust of his lifelong religious quest was the effort to save Christianity by purging it of irrationalities* (my italics. HFC).[45]

This view of what Newton was up to in his most heretical (and, for that very reason, carefully hidden) writings was in its turn part and parcel of Westfall's vision of the fundamental significance of the Scientific Revolution:

> The story of Newton and Christianity constitutes, in my perception of things, one chapter in the central drama of European civilization: the conversion of an originally Christian civilization into a scientific one.[46]

Even in the compass of one short book chapter Westfall did not leave this grand generalization without some empirical evidence:

> When we read only one or two of their refutations of atheism, we may find them impressive testimony, but by the time we read the tenth repetition of the same argument, we begin to sense some uneasiness behind it. Boyle offers a prime example. After a lifetime devoted to the

43 https://www.youtube.com/watch?v=PrVkh86HqEs

44 R.S. Westfall, 'Newton and Christianity'; in: I. Bernard Cohen & R.S. Westfall (eds.), *Newton. Texts, Background, Commentaries* (New York: Norton, 1995); pp. 356-370; p. 368.

45 *Ibidem*, p. 370.

46 *Ibidem*.

> refutation of atheism, he left provision in his will to endow a series of public lectures. What were the lectures supposed to do? Refute atheism some more. *When during the previous fifteen hundred years had that appeared necessary?* (my italics. HFC)[47]

This is followed in its turn by Westfall's point that both Boyle and Newton felt "the ground shifting under the traditional foundations of Christianity", with Newton responding in a different manner than Boyle:

> Instead of trying to shore up the established foundations, Newton attempted to make the central structure secure by abandoning its faulty members. Lest I be misunderstood, let me dispense with the figure of speech and state my proposition in more direct terms. I mean to say that Newton questioned orthodox theology and rejected some of its teaching that he found contrary to reason.[48]

So much, then, for my final panel item, Westfall's breadth of vision. Over and above this and all the other aspects of his life's work here touched upon, Westfall was, though well aware of his worth as a scholar, not one to take himself all too seriously. I doubt whether he would have greatly liked the praise I have been heaping upon his scholarly achievement in these pages. My only defense is that, in his unwitting capacity as my own, not ideal yet overall exemplary historian of science, no one else deserves more than he does the place I have assigned him on the five-panel polyptych that is now completed.

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[47] *Ibidem*, p. 359-360.
[48] *Ibidem*.

Art and the sciences for everyone! The popularization and democratization of science, art, and culture in the nineteenth century[1]

Marita Mathijsen

Introduction

Vincent van Gogh was an avid collector of reproductions. His finances did not enable him to buy original paintings, nor to travel to museums, so he examined reproductions of the great artists with a view to learning from them. Although in his brief Amsterdam period he grabbed every opportunity to spend hours in front of the authentic paintings of, in particular, the admired Rembrandt, he also made sure to collect a large number of prints made after paintings by Rembrandt as well as by many others.

It was along this route that, in the nineteenth century, the enjoyment of fine art came within sight of just about everyone. Van Gogh's collection of reproductions allowed him to master the art canon then current, and what is true of him was true of, indeed, just about everyone. Even contemporaries of Van Gogh who stemmed from lower segments of the population than this son of a vicar got in touch with art along the same pathway of reproductions. Take his famous painting *De aardappeleters* ('The Potato Eaters'). Some careful scrutiny reveals that even the extremely poor peasant family seated there around the table has a reproduction hanging on the wall. The print shows Christ on the cross, together with His mother and with the apostle John. It follows the medieval art tradition, with Mary in

1 Translation: H. Floris Cohen.

blue and John in red, in the manner of Lucas van Leyden, Jacob Cornelisz van Oostsanen, and many others.[2]

For countless families, to get in touch with a reproduction of some painting by, say, Rembrandt or by Jacob van Ruysdael was their way to make their first acquantance with great art. Until the early nineteenth century it is was out of the question for an ordinary mortal to throw even a passing glance at, in particular, great secular works of art. None but art on display in churches was accessible to the public at large – all other art hang or stood in palaces and castles, hidden to all but their owners, their staff, and the occasional noble visitor.

Nor is the phenomenon confined to the arts. In a wide variety of territories closed until then to all but the proverbial happy few, the nineteenth century is marked by a movement of popularization or even of *democratization*, thus opening up these territories to far larger segments of the population. Not only the number of passive but also of active participants in the arts and sciences increases considerably. What makes this possible in the very first place is certain changes in contemporary ideas about society, with modern technologies lending a hand as well. As the French scholar Bernadette Bensaude-Vincent writes: '[…] ce qui caractérise le XIXe siècle, ce sont des tentatives répétées, multipliées, obstinées, pour élargir le public de la science au-delà de la sphère des gens cultivés. La science se "popularise". Mieux, ou pire, elle se "vulgarise".'[what characterizes the 19th century is a whole range of obstinate efforts, repeated and multiplied, to enlarge the audience for science and scholarship beyond the sphere of the cultivated. Science 'popularizes' itself. Better (or worse) it 'vulgarizes' itself.][3]

Speaking quite crudely it may be maintained that, until far into the eighteenth century, the arts and sciences were accessible only to a small social élite. In the early 1700s hardly any public museums exist anywhere in Europe. Libraries are inaccessible to people who are neither academics nor members of the highest regions of church and state. Most music is being played in closed company (although it is of course true that everyone could attend the performance of vocal or organ music in the church, and that folk music sounded at fairs and town festivities). The sciences are being cultivated by small groups, which spread their knowledge chiefly among fellow professionals.

[2] The Van Gogh Museum calls the print a 'huiszegen', but prints in that genre habitually display a sermon as well, which is not the case here (see Gerritse 2021, 46).

[3] Bensaude-Vincent 1997, 13.

Enlightenment ideas

Enlightenment ideas that began to come up in the late seventeenth century closed, but ever so slowly, the vast gap in cultural participation that existed between the general population and the élite. The process took some hundred to hundred and fifty years. It followed from basic Enlightenment principles that art and science ought not to remain confined to a privileged segment of the population. Reason determines what we think; consequently, all of us, in possession as we are of the capacity to think rationally, are equal, at least in principle. But this means that the difference between the élite on the one hand and peasants and manual workers on the other results from lack of education. And what is it that prevents people from developing their rational capacities? The answer is: poverty. So there was a need to enhance chances for people to take part in culture and in the sciences. And this could be done only by means of education and by opening up all kinds of closed circuits of the arts and the sciences.

It is in the wake of the French Revolution in particular that such Enlightenment ideas begin to be practiced on a wide scale. Napoleon enacted laws which took education out of the hand of the church and private institutions and also arranged for inspection by the State. When Napoleon fell most European states stuck to these arrangements or became late adopters. The population's reading capacity and level of education benefited greatly. This led in its turn to a slow yet sure growth in the participation of the lower segments of the population in culture and science. No longer were these closed territories – they became part and parcel of what may be called *the public mental sphere*. This even happened in a literal sense: the paintings that had adorned the walls of King Louis XVI's palace were moved to the public French National Museum, and the Versailles palace was opened for all.

Jonathan Israel is of the opinion that in the eighteenth century the influence of those whom he takes to represent 'the Moderate Enlightenment' was still quite strong. They aimed to conceive of their faith in such a way that it remained compatible with reason. With those who adhered rather to 'the Radical Enlightenment' it was different. After the French Revolution their ideas would become more dominant.[4] It is doubtful whether these

4 Israel 2005, passim and 763-770; Israel 2015, passim.

views of Israel are valid for culture in the Low Countries. There a moderate Enlightenment is paramount, with change taking place slowly, with traditional values being preserved in religion, and with a difference in levels of society remaining intact likewise.

None of this takes away that impressive shifts are taking place in the Low Countries as well. The number of voices heard in public space increases drastically. Here Jürgen Habermas' influential 1962 study *Strukturwandel der Öffentlichkeit* shows the way. He points at two 'metamorphoses of public space' in particular. One takes place in the eighteenth century, under the influence of the Enlightenment. Court culture turns into civic culture. The public sphere in this period is in optimal state, with ample room for rational debate. Public debate flourishes in countless pamphlets and critical journals, as also in many associations. Here the role of the press can hardly be overrated. No longer open for scholars or great literary authors only, the press turns for many groups into a considerable power factor.[5] Kloek and Mijnhardt, in their influential study *1800*, confirm his broad view of the matter. Even though the Netherlands had not known a court culture, the influence of the press rises spectacularly.[6] Habermas' second metamorphosis occurs in the second half of the nineteenth century. The new, civic culture now turns into mass culture, and the rationality of public debate vanishes. Habermas, meanwhile 93 years old, may well be grimsmiling at the unmistakeable correspondence between what he saw as specific for the late nineteenth century and what little rationality present-day debate still appears to possess.

So much for my own carefree popularization of the phenomenal and very widely-flung Enlightenment ideas of thinkers like Voltaire and Kant, and of interpreters like Jonathan Israel and Jürgen Habermas. I shall now present an overview of the phenomenon of popularization that is so characteristic of nineteenth century culture. How did the altered way of thinking of the Enlightenment manifest itself in the Low Countries in everyday life? How did these ideas take shape in the striving for a public space in every segment of society? In case after case I shall show how systematic the effort was to popularize whatever had remained confined so far to relatively small minorities only.

5 Habermas 1991, passim.
6 Kloek en Mijnhardt 2001, 22.

It is as if there is a house with its rooms securely locked, and the key owner suddenly decides to open them. From now on everyone is welcome to enter, and he even goes so far as to kindle a light for those who enter for the first time. Several rooms are unlocked.

This concerns in the first place private collections, be it in the arts or in the sciences. Further, associations and societies open so far to none but a select group of powerful men or academics of the same faith begin to welcome more members. In the Netherlands, for example, Roman Catholics get a chance to attend. New associations are also formed, and these are from the very start less exclusive than those already in existence. As a consequence, newcomers become part of networks that can help them attain a higher social status. This concerns in particular middle-class people, non-academics, catholics, Mennonites and the like. To be sure, women remain excluded as of old, as are Jews, even though the latter have meanwhile been put on a legally equal position with their fellow-citizens. Finally, science and scholarship have so far been cultivated in closed academic communities. In contrast, in the nineteenth century specialized science is widely rendered in more easily comprehensible terms; widely-flung knowledge is taken up in encyclopedias; the meaning of words is defined in dictionaries, and unknown vocabularies are presented and explained.

What greatly furthers all this opening-up is major changes in the printing press – the medium of these changes *par excellence* in those times. New printing technologies make it possible to reach far higher print runs. By the same token, illustrations that help explain sciences like astronomy or anatomy or palaeontology can be printed far more easily and cheaply than before.

The scholarly literature

What research has been undertaken so far on the subject has generally remained confined to national territories and to just one discipline selected among the many that were subject to popularization during the period. For Great Britain Bernard Lightman enlightens us in his *Victorian Popularizers of Science* (2007) about the efforts undertaken by men and women to make the exact sciences, and nothing but the exact sciences, known in the entire population. Likewise, James A. Secord in his *Victorian Sensation* (2000) confines himself to the exact sciences and how these were popularized in a 'cult book' *Vestiges of the Natural History of Creation* that came out anonymously in 1844. There is just one book that covers all the relevant disciplines, while covering the French market only – this is Bernadette Bensaude-Vincent and Anne Rasmussen's *La science populaire dans la presse et l'édition* (1997).

Both Lightman and Bensaude-Vincent raise the problem of a proper terminology.[7] Lightman points at the somewhat negative connotation of 'popularizers' and 'popularizing', yet in the end he finds these terms the most suitable ones. Bensaude-Vincent even considered to speak of 'vulgarization' (which in French has a somewhat different, less negative connotation than in English), but opted for 'populariser' after all. Sharing their concern, I have opted for a somewhat different solution. In what follows I alternate between the 'popularization' and the 'democratization' of the arts and sciences. An admitted drawback of the latter term is that it suggests, to a greater extent than is really justified, the *active* cultivation of the arts and sciences in substantial layers of the population, whereas what is at issue in most cases is just their becoming more accessible. But I do not want to give up the strong point of the term, which is, precisely, the widening process itself. And it is this democratization of the arts and sciences in the nineteenth century that, while paying attention in the first place to society in the Low Countries, I shall now elucidate in six domains: schools; reading; societies; museums and art collections; history, and science.

1. The schools improved

Chances for new ideas, *any* new ideas, to penetrate into wide segments of the population are dependent in the very first place on the height of its education, with the state of its literacy paramount. Indispensable in this regard is the quality of a nation's schools. In the nineteenth century schools change all over Europe. Before the French Revolution school instruction was a matter of private initiative, of the church, and of the local preferences of local authorities. In the Netherlands authorities confined their actions in this regard to schools for just the youngest children of the very poor – those taken to be unable to teach their children themselves. Quite elementary primary schools, with some instruction in just tiny bits of the three Rs: reading, writing, and arithmetic, were thus paid for by the municipality. Whoever wanted to help

7 Lightman 2007, 10.

his children to a school of higher quality had to pay for it himself. Meanwhile the churches often took education in their own hands as well, even if only to help future priests or vicars to their first instruction.

When in 1795 a French army invaded the Netherlands, chased the stadholder away, and oversaw the foundation, by 'patriotic' citizens, of the so-called 'Bataafse Republiek', the founders set out right away to improve the school system. A law to reform the system of primary schools was enacted in 1806 – it was to remain valid for half a century. From 1815 to 1830 it applied to the Southern Netherlands as well, joined as they were during those fifteen years to their northern counterpart in the Verenigd Koninkrijk ('United Kingdom'). True, no subjects other than arithmetic and writing were as yet legally prescribed, nor had school attendance been made compulsory. Even so, cities were obliged to provide for a sufficient supply of solid primary schools, for children of the poor as well as for others. Under King William I the laws were applied to higher education as well, and in more rigorous fashion, too. These new laws applied likewise to the entire kingdom.

Improvement of instruction as such had already been initiated in earlier times by the 'Maatschappij tot Nut van 't Algemeen' (literally 'Society for General Utility', better rendered as 'Society for Public Welfare' or 'Society for the Common Good', and best known in Dutch by the abbreviation 'het Nut', which is to be adopted in what follows as well). Founded in 1784, the Society aimed above all to spread knowledge with a view to personal development and social improvement. It sought to spread a variety of moderate Enlightenment. It founded schools of its own, where bodily punishment of children was abolished, and replaced with a reward program. Pupils were now arranged in age groups rather than indiscriminately thrown into the melting pot. Learning to read was no longer taught by means of the alphabet but by using tools like reading boards which helped a pupil learn to compose simple words from loose letters. When the government reorganized the school system, the 'Nut' naturally collaborated.

The reorganization also involved arrangements for systematic inspection (instituted in 1814 for the entire United Kingdom) of the quality of the schools in the new system. The first training colleges for primary school teachers were opened, and inspectors were appointed. Their reports, which have been preserved, allow instructive glimpses into the kind of wrongs they signalized. In the province of Frisia, for instance, the inspectors found teachers who were able to write letters only, with, for the rest, literacy zero.

Such investment in school education was, of course, an indispensable step toward giving larger segments of the population a chance to take part, be it actively or just passively, in the arts and sciences. It precedes popularization, and makes it possible to succeed.

2. Ways and means to enhance the practice of reading

Such success presupposed likewise the presence of an efficient printing press for the production of schoolbooks, and of a sufficient number of authors capable of turning available knowledge into well-understandable texts. To have more and better schools was therefore dependent on having textbooks of the right kind available in sufficient measure. Similarly, adults who wanted to help themselves to better education needed books to widen their knowledge. Scholars giving public lectures could contribute to the same end as well, though on a more incidental scale.

What ways and means became available to enhance chances in this regard?

Technology first. In the first two decades of the 19th century the techniques for printing and for illustration, as well as for paper production, are still by and large the same as in Gutenberg's time. From the 1820s this changes with spectacular rapidity. The first change is still fairly small: the wooden printing press is replaced by one of iron, which can print twice as many copies as before – still rather small amounts. But then the steam press makes its appearance. In England it is introduced around 1820; Belgium and the Netherlands follow about a decade later. Follows the rotation press, with its round printing forms and paper rolls beside flat sheets. And now the number of books printed in one run grows spectacularly. By the 1840s paper, too, becomes a subject of change – cheap paper made of wood by means of steam power begins to replace expensive rag paper.

At least equally important is the invention of the stereotyping technique, thanks to which the same type can be used for more than just one print run. This greatly speeds up the printing process, and thus enhances production. The production of novels in the Netherlands illustrates this quite well: whereas 23 novels came out in 1820 (translations and reprints included), the number for 1899 is 238.[8]

8 See for this Mathijsen 2021, 238.

Not only do vastly more books appear, the quality of their illustrations is enhanced as well, thanks to the invention of lithography and, later, of photography.

All in all, the number of printed titles rose enormously; one print edition could count vastly more copies; circulation increased, and books could become a good deal cheaper. Add to this that average income rose, too and that people came to dispose of more spare time and (with the advent of gas lighting) of better illumination at home, so that individual reading became easier as well.

Not that technological innovation is all there was to expanding literacy. Take the opening up of libraries. In 1692 the French King had made his Library accessible to a small élite (on recommendation only, to be sure). In the very first year of the Revolution it was transformed into the Bibliothèque Nationale that it still is, with entrance both made easier and guaranteed.

Something similar happened with the books that successive Dutch stadhouders had collected. They followed a policy like that of Louis XIV – entrance at specified hours only, for members of the élite in possession of a rarely granted letter of recommendation. In 1795 their library was confiscated and opened to everyone. And yet the National Library in The Hague (later renamed the Royal Library) has never become a place for everyone. The Royal Library really remained about as much of an élite institution as (with their necessarily limited access) the university libraries and society libraries were. The same applied to their counterparts abroad. Even around 1980, when I spent weeks in the British Library, I had to present a letter of recommendation, written by my thesis supervisor, before I found myself seated under its famous dome.

It was other, newly founded libraries that truly gave the common man access and that, in so doing, served him quite well. In 1850 the House of Commons passed the Public Libraries Act. It gave municipalities the right to found public libraries, which did indeed attract readers from all segments of society. In the Netherlands 'het Nut' stimulated from day one of its very existence the foundation of such libraries. Its shelves came to house simple books for town dwellers as well as people living in rural areas. The authorities aimed for nothing less than the well-planned popularization of knowledge leading to what we might call a 'velvet revolution' – a very effective yet non-violent revolution, that is. The wrongs against which the French revolutionaries had done violent battle could, then, be resolved in the trusted vein of the

Dutch ‘polder’, that is, by compromise after compromise in a spirit of mutual acceptance. If helped to assert themselves better, so was the idea (and the practice as well), people would be less inclined to turn their justified anger into uncontrolled fury. In 1791 (four years before the French invasion, that is) Haarlem was the first city with a ‘Nut’ library, with the books on its shelves being purchased thanks to gifts from the higher bourgeoisie. No book came to adorn those shelves without prior approval by the vicars who usually ran such a library. So there were many religious books, but also accessible short works about zoology or paedagogy or hygienics (books of the two latter types naturally filled with useful recommendations). Present-day readers would stay as far away from such a library as they possibly could. If certain books deemed useful did not yet exist, the ‘Nut’ simply invited authors to compile one. That is how booklets hit the market about the spelling of words, about smallpox vaccination, or about physics made simple; all this with a view to set mistaken ideas about the subject right. As time went on, the ‘Nut’ libraries also began to put novels on their shelves, thus helping them to become popular for the first time. In 1890 there were 340 ‘Nut’ libraries (not counting those meant exclusively for the young).[9]

Commercial libraries, not dedicated as such to the aim of enhancing people’s knowledge, knew how to cater to their readers’ taste with light-hearted, erotic and/or suspense-providing reading matter. Here the borrowing of books was not for free. Eager readers could get their fill of translated novels by, for instance, Paul de Cock, James Fenimore Cooper, Edward Bulwer-Lytton, Carl Spindler, Heinrich Zschokke, or Alexandre Dumas. Original Dutch novels by meanwhile wholly forgotten authors like van Buren Schele, Bosdijk, or Krabbendam were also being lent there. The combination of technological progress in printing and increasing literacy served to make these libraries flourish. Here education, moral instruction, and the expansion of knowledge were not the point – the whole point was, rather, the sheer pleasure of reading stories.

The state remained out of the entire development here described – the first state-funded public library in the Netherlands dates from 1899.

In Belgium the first public library was founded in Antwerp in 1911. Before, the general population could go, beside commercial libraries, to libraries

9 Dongelmans 2000, 181. This concerns 340 ‘Nut’ departements with a public library and 25 with one especially for youngsters.

meant specifically to further Flemish reading. These were set up by funds like the Willemsfonds and the Davidsfonds. Ghent was from 1840 onward in possession of C.J. van Ryckegem's reading room, where Flemish titles were lent for free. So in Belgium, too, people of small means got far more chances than before to read books.

One further resource for the spreading of knowledge were journals. Ordinary readers could not afford to take a subscription, but there were café's and reading rooms with a variety of journals lying ready for the avid reader. The journal supply rose in the course of the 19th century, and various periodicals aimed specifically at popularization. One example is *Het Leeskabinet*, which regularly published articles aimed at spreading not particularly profound knowledge on topics like prehistory or the way of life of foreign peoples.[10] Journals of a broadly cultural outlook contributed to the same end, though at greater depth. In journals like *De Gids* or *De Vaderlandsche Letteroefeningen* 'Miscellaneous' sections always published numerous pieces in which new scientific developments were elucidated. So did British counterparts like *Blackwood's Edinburgh Magazine* or the *Quarterly Review*. As Laura Otis noted in her study on contributions of literary fiction to knowledge about what went on in science and scholarship: 'In nineteenth-century periodicals, magazines, and newpapers, articles on scientific issues were set side by side with fiction, poetry, and literary criticism'.[11] Even Charles Dickens' well-known family periodical *Household Words* had a place for articles on chemistry and anatomy. But there were also journals directed toward spreading knowledge in one specific domain among common readers, be it agriculture or mathematics or theology or history or physics. We should not entertain any illusions about the intellectual level of the articles in such journals, witness topics like cannibals, wolf-children, wolves devouring each other, or 'speedy poisoning by means of brandy'.

Early on in the nineteenth century, booklets of a popular-scientific nature still often work with the familiar 'question and answer' format, even if directed at adult readers. But authors bent on popularization very quickly teach themselves basic techniques of accessible writing. If we compare history schoolbooks in the first decades of the century with later ones, we notice how barren listings and enumerations make place for juicy and gripping story-telling. The first scholars to use literary techniques for their

[10] Mathijsen 2004, 155.
[11] Otis 2002, XVII.

writing are historicans: solid investigators like Jules Michelet, Thomas Macaulay, Augustin Thierry, or Leopold von Ranke wield their pens as if they were Walter Scott himself.

3. The opening up of societies and other cultural circles

So far we have examined *conditions* for popularization – a sufficiently literate population, and sufficient ways and means available for it to gain access to books and journals dedicated to the increase of knowledge. However indispensable, more is still needed for participation in the arts and sciences and in culture in general.

To exchange views and ideas about immaterial things presupposes access to circles with the same interest or to groups where specialists share their knowledge. Popularization, after all, does not take place in writing only; the spoken word has a role of its own to play. Who could become a member of some learned society; were societies in existence that invested energy in spreading the knowledge discussed in their midst; were there circles of amateur investigators and of lovers of culture? The oral transfer of knowledge could take place in all kinds of locations: in the church, in salons, in institutes, in theatres, in café's, in reading clubs, and in associations of the most diverse kinds.[12]

In the Netherlands we cannot fail to find the 'Nut' crossing our pathway. Its literally hundreds of departments organized instructive lectures for its members. Often some ten lectures were being held in the winter season, most often by the local élite – the vicar, the physician, the pharmacist. All kinds of topics could come up in such a lecture, be it in physics or in history or in pedagogy or in rules for right conduct. Whether women could gain access depended on what topic had been chosen. From 1858 onward the 'Nut' went so far as to organize lectures specifically for workers, the so-called 'volksvoorlezingen' ('popular lectures').[13]

How about the other societies? Some remained as closed as they had always been, and remained as far removed from transmitting their knowledge as they had always been. This was, and is, true of, for example, the

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12 Lightman 2007, 17.

13 Leenders 1996, 164. Buitenwerf-van der Molen 2007 may be consulted about the popularization of modern-theological thinking through lectures, books, and other means.

'Maatschappij der Nederlandsche Letterkunde' ('Society for Dutch Literature') – then as now open for membership through the ballot only, and with lectures where none but the members may attend. Other societies quite explicitly aimed at spreading their knowledge. In many towns there were scientific societies, some of them directed at popularization, such as the Arnhem society *Prodesse conamur* ('Our striving is to be useful').[14] Medical societies remained confined as a rule to the professionals, but these doctors did lend themselves to giving lectures for 'het Nut'.

The literary societies, which in the eighteenth century consisted as a rule of a circle of men (or just on occasion women) who cultivated poetry, changed character. They began to direct themselves more to people who loved literature and liked to come and listen to presentations (often recitals) by more or less well-known literary authors. Lectures about science and scholarship were not given in such societies, but historical topics could become the subject of a lecture.

To sum up. Whereas some learned societies remained closed, others promoted popularization. This was true in particular of those that covered in their public lectures a wide terrain, with subjects running from chemistry to philosophy and from history to the arts. For amateur historians, for example, it became easy to become part of some network – local investigators could found antiquarian circles, where its members might well publish a journal of their own. Researchers in other domains, such as medicine or science, did not so easily gain access to professionals circles, unless they had an academic background of their own.

4. Art for everyone in museums and collections

Take Teyler's Museum in Haarlem. It is an early example of the urge to make the arts and sciences accessible to a wider public than just professionals and members of the élite, but it is no less a showcase of the encyclopaedic breadth of the interests of those who did the collecting. Still today visitors can watch there at their ease an art collection; fossils and minerals gathered from all over the world; physical demonstration instruments, and even an observatory – all of them collected or constructed in the late 18th and early 19th century.

14 Snelders 1983, 107.

Indeed, such encyclopaedic strivings are a product of the 18th century. One collector (in the case of the museum, Pieter Teyler – an Enlightened, wealthy Haarlem merchant) could bring paintings, coins, rocks, animal species, really anything else, together on one spot, with on occasion quite impressive results. Such encyclopaedic collections were brought to order according to some classification system or other. In some cases they were open to well-selected members of the public, if equipped with a letter of recommendation and if arriving at one of the few hours the doors did not remain closed for everyone. This rule applied irrespective of whether the collection was owned by a private person or by scientific institutions or even by princes. The one museum to which this rule does not apply is the Ashmolean in Oxford, which was founded in 1683 and is generally regarded as the first genuinely public museum in Europe. Here antiquarian, ethnological, and natural history objects were brought together, in the company of a voluminous library. Another early example is Czar Peter's collection, which was displayed in the impressive new museum of the Russian Academy of Sciences and, as such, open to the public from the very start. The collection spread itself rather thin, with insect preparations as well as Siberian antiquities on view.

The British Museum, that opened its doors in 1759, was initially a typically encyclopaedic museum. Antiquities and naturalia predominated. The foundation act stipulates that the collection should be there 'not only for the inspection and entertainment of the learned and the curious, but for the general use and benefit of the public'.[15] Even so limits were set to accessibility – a written request had to be handed in beforehand. Nor did this rule change when in 1823 the impressive building began to be constructed which still houses the museum today.

As the century went on, the encyclopaedic museums began to split themselves up over more and more specialized domains, such as museums for the arts, which were then further subdivided in museums for European early art and modern art, respectively. Separate museums for classical antiquity were also set up, and filled with antiquities dragged away from Egypt, Greece, or Italy. One of the earliest among these was the Rijksmuseum voor Oudheden in Leyden (1818). Scientific collections, too, began to be housed in museums of their own. This applied in particular to museums for natural history, or for fossils, such as the Rijksmuseum voor Natuurlijke Historie in Leyden, which opened in 1820. Here stuffed animals, shells, and other natural phenomena

15 Quoted from www.britannica.com (March 29, 2022).

held to be educational could be admired by whoever appeared at the entrance door. All of Europe came to house such museums. Even zoo's may be regarded as museums, not of stuffed animals of course but of live ones. 'Artis' in Amsterdam was called a living biology book (1837).

The shift just described was a natural consequence of the 19th century growth in knowledge, with ongoing specialization as one consequence thereof. The need for universal learning was felt less and less.

Another phenomenon of the time is the commercialization of knowledge. As could be expected, there were smart-alecks who managed to exploit the thirst for knowledge commercially by setting up cabinets with stuffed animals; by founding collections of wax figures, or by building panorama's with representations of glorious battles. When the World Exhibition in the Crystal Palace was closed in 1851, it opened a department with dinosaurs reconstructed at their true size. And when in 1859 Darwin published his *Origin of Species*, the voyager and anthropologist, Paul du Chaillu, made a trip all over England with lectures that accompanied his collection of ape heads. During his exploration of Africa he had arranged for their decapitation in person, and taken the heads home. His gorilla skulls were meant to elucidate Darwin's theories.[16]

Wax figure museums were commercial institutions likewise. Early on in the nineteenth century the Swiss physician Philippe Curtius prepared models of human organs in wax for teaching purposes, and then went on to produce wax figures of well-known persons, which he put on display in Paris. He taught his assistant, Marie Tussaud, the tricks of the new trade, and when she moved to London she first set up a touring exhibition, and then, in 1835, a real museum. Her example was followed all over Europe. Amsterdam had the 'Nederlandsch Panoptikum', where historical characters as well as special events were cast in wax and displayed in exchange for payment.

Panorama's are likewise a phenomenon of the second half of the nineteenth century. These were huge, round tents where the public could get together at the center and look around for many a detail of, for instance, a military battle pictured with historical precision. Brussels, for instance, housed the Panorama Castellani with the Battle of Waterloo on circular display.

Whether it was knowledge of history or of the natural sciences, it became a product, dependent on mass sales. The time was past when people out to

[16] Lightman 2007, 2.

make the world a better place made their knowledge widely available for wholly unselfish reasons. Public space had become a matter of the masses, precisely as Habermas has pointed out.

We return to the museums for the arts. During his European conquests Napoleon had kept commanding his troops to rob the best works of art they encountered in the royal or city collections of the countries they conquered, and to transport them to Paris for the European Museum he wanted to found there. After Waterloo the largest part returned to their respective homes. These return trips had for paradoxical consequence that in various countries a catching-up movement got speedily underway to found national museums, precisely because the paintings and sculptures had gained so much in national significance. Amsterdam and The Hague, Brussels, Madrid, Milan, Munich, Parma, Rome, and Vienna are cities that in retrospect benefited from the emperor's robbery.

In the story of the art museums and the spread of knowledge of art, reproductions of the kind we already met in the case of van Gogh are relevant as well. Reproduction techniques widened thanks to lithography and photography. Remarkably, the oldest known foto picture, made by the French photograper Joseph Niépce in 1825, was made after a seventeenth century engraving, which makes it the first photographic reproduction of an art work as well. Some paintings acquired cult status the way pop stars were to do later, and in such a case reproductions were a welcome byproduct. In this manner *The light of the world* by the English pre-Raphaelite painter William Holman Hunt traveled all over the world. At the entrance not only tickets could be purchased, but those reproductions as well. The name given to the shops where one could buy reproductions was 'the poor men's galleries'.

To recapitulate. Enjoying the arts was no longer restricted to highly select company. Thanks to the opening up of museums already in existence and the founding of new ones, the common man (and the common woman, too) gained access to the beauty of the past, which enabled him to join in the establishment of the art canon of the time. The invention of certain reproduction techniques, thanks to which beloved works of art could enter the home sphere, reinforced the effect. But there were also the science museums, where the visitor could make himself acquainted with, for instance, the diversity of the animal kingdom or of the rocks in the earth. Some museums also carried out experiments in public. Teyler's Museum, for instance, boasted (as it still does) the largest friction electrostatic machine in the world. Meanwhile the commercial panopticums, panorama's, and wax figure museums divulged knowledge in their own way.

5. The cultivation of history

It could almost be called a fashion: so-called 'vaderlandse geschiedenis' (literally: history of the fatherland). In an earlier study I have called the phenomenon 'historiezucht' ('history addiction').[17] The number of practitioners increased drastically, in two quite distinct ways. Inspired by 17th century British antiquarians, amateur historians began to investigate remnants and sources from the past, and artists and literary authors appropriated the past for their own purposes. Indeed, nothing served so much to popularize the past and knowledge about it as the historical novel and the historical epic did. 'The democratization of history' is quite the fitting metaphor here: the number of 'voters' increased quite considerably.

For decades the historical novel was the most popular reading genre throughout all of Europe, and in a sense Walter Scott is responsible for that. He grounded his novels in real stories about the past that were still being passed on here and there, and his novels point at the sources he had found for some story. This had never been done in fiction based on history. Those who followed Scott's habit in their own novels and poems sought, by means of footnotes and comments, to document the actual facts underlying their story as accurately as they could. The love story served for decoration only, the true value of the novel rested in the historically correct description of regions, habits, clothes, power relations. For instance, Hendrik Conscience added to *De Leeuw van Vlaenderen* ('Flanders' lion') historical notes in which he quoted old sources to the letter.

Artists, too, set out to appropriate history for their own purposes. Historical painting flourished, with a predilection for crucial events, for the 'moments suprêmes' of the past. Pertinent examples are paintings and drawings dedicated to the murder of William the Taciturn, or to the very moment before the beheading of the young English queen Jane Grey. Recent history counted, too, as with the painter Gustaaf Wappers recording the drama of the Belgian insurrection.

17 Mathijsen 2013.

Popularizing history books were among the most frequently read books of the 19th century. Whether one looks around in 1800 or in 1890, among books with many reprints those on history are invariably at the top. One example is Jacob van Lennep's *Voornaamste geschiedenissen des vaderlands* ('The most important histories of the fatherland'), which he wrote originally for children but which many an adult came to appreciate as well. His history books were reprinted no less often than his historical novels. Hendrik Conscience wrote an accessible and also popular *Geschiedenis van België* ('History of Belgium') which hit the market in all kinds of formats. School textbooks on the history of the fatherland were reprinted all the time. In 1801 the 'Nut' published such a book (*Schoolboek der geschiedenissen van ons vaderland)* written by the schoolteacher Hendrik Wester. Sixteen years later it was reprinted for the seventeenth time.

The cultivation of history by amateurs did not in any way replace élite activity in the sphere of the academy. For the first time the state appointed archivists, who began to publish documents from the past. Thus Guillaume Groen van Prinsterer, who became head of the Oranges archive owned by the King, published from 1835 on the correspondence of the successive stadhouders – a project that would, in the end, amount to 26 volumes. The Gelderland archivist Is. A. Nijhoff founded the journal *Bijdragen voor de Vaderlandsche Geschiedenis en oudheidkunde* ('Contributions to the history of the fatherland and to antiquarian knowledge), all for the benefit of his co-professionals. The same Nijhoff published not only documents from the past of his province but also books for far larger audiences, such as *Arnhem en zijne omstreken* (1854; 'Arnhem and its environment') or *Kort overzigt der algemeene geschiedenis, voor jonge lieden* (1823; 'Brief survey of general history, for youngsters'), both of which were often reprinted.

Something comparable is true of the history of Dutch literature. The number of academics grew who specialized in a genre that in previous centuries had not even existed. Medieval texts were discovered, edited, and given in print. For the first time those interested could make their acquaintance with *Reinaert de Vos* of with *Beatrijs.* No historical overviews had been written until 1800, but then it all went quite fast. A canon of memorable literary works was created which, remarkably, has hardly changed since. The expression 'The Golden Age', (meanwhile fallen in disrepute in the Netherlands in view, chiefly, of the flourishing of the slave trade at the time), was created in this time, and applied to literature. Once again all this did not remain confined to academics. Popular editions of important writers of the seventeenth century likeVondel and Cats saw the light of day and sold quite well. The young were even provided with a biography of Vondel, written by H. Zeeman: *Het leven van Joost van den Vondel, een lettergeschenk voor de jeugd* (1831). Belgium erected a statue for its own canonical author, Jacob van Maerlant. In the Netherlands the same was done for Vondel and for Cats.

To sum up. History was cultivated in far larger measure than before; academics did not feel embarrassed by adapting the outcomes of their investigations to readers with little relevant knowledge; artists and literary authors immersed themselves in history, and ensured that almost obsessive attention was being given to the past. Works on history were among the books best sold in the 19th century. Commercialization of historical knowledge is certainly part of the picture, too, witness the wax figure museum, the panopticums, and the panorama's with scenes from history that we discussed in the previous section.[18]

6. Science and scholarship

The first step in the direction of the systematic enhancement of knowledge consisted of encyclopedia's. When the genre came up in the late 17th century it had another purpose – to bring together knowledge from all over its manifold branches. The famous *Encyclopédie* of the Enlightenment period, while covering all domains of science and scholarship, was written by and for the élite. But soon the audience aimed at in the first place began to change.

The encyclopedia's that came out in the Netherlands were at first called dictionaries, yet the extensive nature of their lemma's made them encyclopedia's all the same. The first one was the *Algemeen woordenboek van kunsten en wetenschappen voor den beschaafden stand en ten behoeve des gezelligen lezers,* compiled by Gerrit Nieuwenhuis and published between 1820 and 1829 in eight volumes.

At a later stage publishers did begin to use the term term encyclopedia. From 1857 to 1859 the Roelants firm in Schiedam published the *Volks-encyclopaedie* in three volumes, followed by a 15-volume *Algemeene Nederlandsche encyclopedie voor den beschaafden stand* that was put on the market by a publisher in Leyden and one in Zutphen between 1864 and

[18] Everything stated and listed in this section goes back to my book *Historiezucht*: Mathijsen (2013).

1868. The encyclopedia that was to become a household word for generations to come (not driven from the market until the advent of Wikipedia) was the *Winkler Prins Encyclopedie*, the first volume of which came out in 1870. Twelve years later its volume 16 completed the first print run.

To what extent scientific knowledge was being popularized may be inferred from the flourishing of the market for cognitive books written for the common man and woman. Whether it was geography or medicine or astronomy, in these and countless similar domains investigators proved ready to exploit their knowledge for the benefit of interested outsiders. Particularly striking is that even in the case of fiction the underlying science was explained– a reader taking in the adventures related in Jules Verne's novels was served by the same token with up-to-date information about the latest discoveries. The most telling example in this regard is perhaps his *De reis om de wereld in tachtig dagen* (*Around the world in eighty days*), which taught the reader quite a few things about time differences, the equator, and all kinds of anthropological findings.

A book series entitled 'De Volksbibliotheek' ('The People's library') that began to appear about 1845 lends itself perfectly well to demonstrate the wide variety of topics up for popularization. One could take a subscription for 22 ½ cent per booklet. The book series included introductions to chemistry, physics, fauna and flora, human anatomy, medicine, hygienics, geography, statistics, logic, morality, cattle breeding, and also some more humanities-oriented disciplines like grammar and the history of literature.

Clearly aiming at the need people of quite limited means felt for good introductory texts, the publisher H.W. Weytingh managed to involve some eminent scholars. For instance, the well-known Amsterdam professor Gerard Vrolik contributed to the series a volume on human anatomy and physiologie (*Anatomie en physiologie van den mensch*).

In Belgium we observe the same phenomenon of outstanding scholars writing cognitive books for laymen, such as a translated version of *Volkssterrekunde* ('Popular astronomy'; 1845) by Adolphe Quetelet, or *Eerste grondbeginselen der wysbegeerte* ('First principles of philosophy') by Egide Hanegraeff, or *Volksgezondheidsleer* ('Popular hygienics', 1866) by Theodoor de Backer.

Books directed at the transmission of knowledge to youngsters came out both north and south of the border. In the Netherlands we encounter, beside the genre of the textbooks for school, titles like *De kleine natuurkundige, of uitspanningen, die op natuur- en werktuigkunde gegrond zijn* ('The little physicist ...'; 1869) by P. Beets. Even earlier A.B. van Meerten Schilperoort had published an attempt at explaining physics to girls (1831).[19] Belgian youth was also properly taken care of, as with the *Klein historisch woordenboek van de oorsprongen, uitvindingen en ontdekkingen* ('Little historical dictionary of the origins, inventions, and discoveries';1846), or the *Kleine diergaarde voor kinderen* ('Little zoo for children'; 1837) by J.B. Courtmans.

Journals played a significant role in popularization as well. The scientific journal *Het album der natuur* could boast 3,000 subscriptions, but even that large number was royally superseded by the geographic/anthropological journal *De aarde en haar volken* ('The earth and its peoples'), with 10,000 subscribers right at the start in 1865. The contemporary book historian Kruseman noted about *Het album der natuur* that it was among the first efforts to popularize science: 'The public at large looked up with respect and interest at that celebrated phenomenon of science, yet with the sole exception of fat, boring, and expensive study books it had too little occasion to get in touch with it. […] It found approval with both men of science and the educated public.'[20] There were more journals that aimed to spread one specific aspect of knowledge among the common people, such as *Magazijn voor de rekenkunst* ('Magazine for arithmetic'; 1828-1835), or *Het welvaren des huisgezins: tijdschrift van gezondheidsleer voor het volk* (1851) on hygienics. We already saw that general journals of high standing also kept their readers abreast of such developments. There were further typical journals for spreading knowledge in a broad sense.

Prestigious publications with democratized science became popular as well among the more well-to-do. Now that the common man was taking part, too, they began to feel a need to showcase their interest in the latest knowledge through the ostentative display of luxury editions. One example is a costly five-volume work *Europa in al zijn heerlijkheid geschetst* ('Europe sketched in all its glory'), which appeared from 1877 onward. What makes it such a status symbol is its beautiful wood engravings 'after original drawings', and a cover stamped with gold. The text was written by a literary author, Gerard Keller. But suitable authors could be found

19 The book was reviewed the *Vaderlandsche letteroefeningen* of 1832. If we can trust *WorldCat*, no copy has been preserved in any library worldwide.

20 Kruseman 1886, 392.

closer at home just as well – certain scientists were perfectly capable of presenting their science to larger audiences. In Britain some outstanding researchers were well-known for their gift to render complicated matter in well-comprehensible language, with the physicist John Tyndall and the biologist Thomas Henry Huxley as the prize examples. In the Netherlands the Leyden astronomy professor Frederik Kaiser had a reputation for presenting his discipline in popularizing publications in so attractive a manner that readers began to undertake their own observations of the sky.

A final proof of the democratization of science is that the universal language of the learned, Latin, which had been the principal language of science for so long, ceased to be used even in professional publications. Even doctoral dissertations, which it was obligatory until far into the 19th century to write in Latin, now appeared in the vernacular.

A summary and a recommendation

Using examples from the Dutch language domain primarily, I have sought to demonstrate how, through the opening of libraries and societies to a far larger public, open networks could arise; how the presentation of specialized science in comprehensible words caused it to reach broad audiences; how the vast increase in the production and the possession of books enabled a vastly enlarged public to gain knowledge of science and culture, and how, thanks to enhanced schooling, these audiences proved eager to receive the gift.

In the full domain of the history of science its popularization is an important yet still too little investigated area of interdisciplinary and international research. How science spread and how discoveries were applied, may be clarified further by means of conclusions to be drawn from an investigation along such lines. What research has been undertaken on the subject so far, remains confined mostly to national areas and to some specific scientific discipline. What is needed, therefore, is more extensive and also more comprehensive research. Such research would be so much grist to George Sarton's mill. During his long life he appears to have been concerned, among a vast number of other subjects, with the spread of scientific knowledge among those not academically educated. It was that particular concern of his that made him cooperate in the foundation of libraries for children in Ghent. 'Sarton saw himself as a socialist and promoted social reform', as Lewis Pyenson and Christophe Verbruggen write.[21] Hence, to expand the history of science to cover as well the history of its popularization in many countries and in many disciplines would, apart from its other virtues, serve as a welcome tribute to Sarton.

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21 Pyenson, Verbruggen 2009, 61. For the libraries for children see Verbruggen, Carlier 2009.

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Laudatio Jean-François Gerkens

S.Vandenbogaerde

On 13 January 2020, I had the honour and pleasure of nominating Jean-François Gerkens for the Sarton Medal on behalf of our law faculty. That nomination was endorsed by all colleagues of the Ghent Institute of Legal History and agreed upon by the faculty and the Sarton Committee of our University. This all happened *in tempore non suspecto*, until some virus halted all activities. With a sigh of relief, we could in October 2021 pick up one of those fine traditions and proceed to officially hand over the Sarton Medal to professor Gerkens for the academic year 2020-2021.

Jean-François Gerkens personifies the Belgian. Born and raised in Eupen, capital of East Belgium (*Ostbelgien*), he knows how to express himself fluently in the three national languages. At the *Collège Patronné d'Eupen*, today known as the *Pater Damian Sekundarschule*, he developed an interest in engineering. However, the young Jean-François changed his course and opted to study law in our sister university at Liège. He obtained his *licence* – today's master degree – in 1991. During his studies, he must have impressed the then professor of Roman Law, Roger Vigneron who asked the graduate to become his assistant. So he did. Six years later, Jean-François made his mark with his successfully defended PhD, "*Aeque perituris..., une approche de la causalité dépassante en droit romain classique*" which showed an extraordinary quality. The gates of academia opened and Jean-François Gerkens eventually became a professor at the University of Liège. Today, he teaches introductory courses in private law, comparative law (in French and English) and, of course, Roman law. He does so not only for students in Liège or Rome, but even in Burundi.

Jean-François' interest in Roman law and comparative law finds its roots in the intense ties with Italy. As an exchange student, he went to the University of Ferrara, where he studied *diritto bancario*, *diritto costituzionale* and *diritto privato comparato*. As an assistant, he followed the *Corso di perfezionamento in diritto romano* at La Sapienza in Rome. There he laid the foundations for future collaborations and friendships.

About 100 publications show an impressive track record. He started in the renowned *Legal History Review*, after which he kept writing in French, German, English, Italian and Dutch. Of course, his emphasis lays on Roman law, but Jean-François Gerkens also pays attention to the foundations of Belgian and French civil law and the history of the legal profession and education as well. His expertise has been acknowledged by the *Tijdschrift voor Privaatrecht*, which awarded him the TPR Exchange Chair in 2008-2009, as a result of which Jean-François moved to Tilburg to teach. He has presented his research at numerous national and international meetings.

Jean-François Gerkens is a member of the editorial board of several leading journals, including the *European Review of Private Law*, and he has a seat leading associations in the field of legal history and comparative law. In addition, he is member of the so-called *Vereniging voor de Vergelijkende Studie van het Recht in België en Nederland* (Association for the Comparative Study of the Law of Belgium and the Netherlands).

Most important however is that Jean-François heads the *Société Internationale Fernand De Visscher pour l'Histoire des Droits de l'Antiquité*. This association is the largest dedicated to the study of law during the antiquity. Once again there is a link with Ghent, since it has been founded by Fernand De Visscher who was born here. The association travels around the world and unites each year a few hundred scholars. In addition, Gerkens is editor in chief of that association's journal, the *Revue Internationale des Droits de l'Antiquité*. Further on, he coaches Liège students for the International Roman Law Moot Court, wherein young people from Oxford, Cambridge, Trier, Naples, Vienna and Tübingen compete against each other.

Enumerating all academic achievements is impossible in this brief presentation. It should suffice to say that colleagues at home and abroad unanimously acknowledge Jean-François Gerkens as a great legal historian and an expert in the field of Roman law. But, perhaps more importantly, they all praise him for his great personality, a perfcet combination of *savoir* and *vivre*. He has that from no strangers as I could witness myself. A few years ago, I met his parents after the best football team was sent home to Bruges after it drew against Eupen on the *Kehrweg*. The game's subsequent discussion took place in a pleasant atmosphere. To be brief, the professional cooperation with colleague Gerkens did not only lead to a smooth exchange of knowledge, but also to a good personal relationship with all members of the Gent Legal History Institute.

In his exposé, Jean-François Gerkens will take us to a cruise on the Mediterranean, where we will search for Graham Island – or was it called Ferdinandea or Île Julia? – an underwater volcanic island near Sicily, which has, on more than one occasion, risen above sea level. What does that has to do with law? You are about to find out.

The Graham Island Case

Acquiring by Occupatio

Jean-François Gerkens

Graham Island – or Isola Ferdinandea – is a mysterious island of the Mediterranean, causing an interesting and complicated diplomatic problem. The aim of this article is to ascertain whether Roman law can provide a clear and useful analytical tool for understanding and possibly resolving this problem.

1. The Graham/Ferdinandea case

It is well known that the italic peninsula has an important seismic activity. South of Sicily, some islands are the result of this volcanic activity, like for example the island of Pantelleria. Not far from there, in 1831, an island rose from the sea and this is also the island this paper is about. For this purpose, I will be going through the available sources[1].

The first source I'd like refer is a speech given by a geologist of the University of Catania, in Sicily: "Relazione dei fenomeni del nuovo vulcano

[1] For a longer version of this story, written by historians in recent times: see Salvatore Mazzarella, *Dell'isola Ferdinandea e di alter cose*, Palermo 1984; Bruno Fuligni, *L'île à éclipses. Apparitions et disparitions d'une terre française*, Paris 2017. Some international scholars and celebrities visited this island and wrote detailed reports. See e.g.: Carlo Gemmellaro, *Relazione dei fenomeni del nuovo vulcano sorto dal mare fra la costa di Sicilia e l'isola di Pantelleria nel mese di Luglio 1831*, Catania 1831; Friedrich Hoffmann, "Ueber das im mittelländischen Meere entstandene vulkanische Eiland, genannt Corrao, Nerita, Isola Ferdinandea, Graham Island, Hotham Island und Julia, nebst einigen Nachrichten über kraterförmige Inseln ähnlichen Ursprungs", in Annalen der Physik und Chemie 24 (1832), p.65-109; Constant Prévost, "Notes sur l'île Julia : pour servir à l'histoire de la formation des îles volcaniques", in Mémoires de la Société Géologique de France, 1835, p.91-124; Sir Walter Scott, "Letter to Mr. James Skene", in John Gibson Lockhart, *Memoirs of the life of Sir Walter Scott, Baronet*.Volume the seventh, London 1838, p. 325-328.

sorto dal mare fra la costa di Sicilia e l'isola di Pantelleria nel mese di Luglio 1831[2]". Carlo Gemmellaro opens his speech with a reference to Seneca[3], who discussed such a phenomenon already during the Antiquity. The Sicilian professor admits that the phenomenon is not especially rare, but it's the first time that so many scholars from so many countries were able to observe the phenomenon in person[4]. He himself tells how difficult it was to persuade a sailor to sail to this volcano[5].

On the 28th June 1831, an earthquake could be noticed on the southern coasts of Sicily and even until Palermo[6]. Two British boats called HMS Rapid and Britannia, based in Malta, were cruising some 30 miles off the coasts of Sicily, between the city of Sciacca and the Island of Pantelleria, and were shaken by this quake[7]. This indicated some volcanic activity nearby[8]. During the first days of July, fishermen from Sciacca noticed some uncanny movements in the sea[9]. Other small boats also noticed some unusual underwater activity and especially many dead fishes, as well as black floating pumices[10].

On the 9th July, Sicilians could smell some odour of sulphide coming from the sea and it sufficed to make silverware turn black[11].

On the 12th July, Ferdinando Caronna, captain of the Psyche from Naples, seems to have been the first to see smoke coming out of the sea[12]. Or at least, that's the version to be read in the Malta Gazette, because Gemmellaro[13] writes that it was another sailor – the Sicilian captain Trefiletti – who saw it already 4 days earlier.

Mentioning the "Malta Government Gazette" probably imposes to briefly explain what it is. In those years of the beginning of the 19th century, Malta was under British rule and there was no freedom of press. We're

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2 Gemmellaro, *op.cit* (n.1).
3 Seneca, *Naturales Quaestiones*, VI, 21.
4 Gemmellaro, *op.cit* (n.1), p. 1-5.
5 Gemmellaro, *op.cit* (n.1), p. 6.
6 Gemmellaro, *op.cit* (n.1), p. 7; Hoffmann, *op.cit*. (n.1), p. 71; Mazzarella, *op.cit* (n.1), p.73-75.
7 Gemmellaro, *op.cit* (n.1), p. 7-8.
8 Gemmellaro, *op.cit* (n.1), p. 8; Mazzarella, *op.cit* (n.1), p.77-80.
9 Gemmellaro, *op.cit* (n.1), p. 8; Mazzarella, *op.cit* (n.1), p.80-81.
10 Gemmellaro, *op.cit* (n.1), p. 8-10; Mazzarella, *op.cit* (n.1), p.82-83.
11 Mazzarella, *op.cit* (n.1), p.87.
12 Malta Government Gazette, Wednesday 27 July 1831 (n° 1069), p.227. In the previous journal [Wednesday 20 July 1831 (n° 1068), p.220], the first notice of smoke was considered to be from 13 July and attributed to Prospero Schiaffino and Mario Provenzano.
13 Gemmellaro, *op.cit* (n.1), p. 9; See also: Hoffmann, *op.cit*. (n.1), p. 72.

thus reading a newspaper issued by the government itself and this is also what the government means to do. They are not pretending to issue an independant journal. For the Belgian reader, the similarity with our "het Belgisch Staatsblad" is probably striking. Having two columns with the same texts written in two different languages is something Belgians are very used to! The design is familiar to them, even though in 1831, the Belgian official paper was not yet bilingual and still called "*Bulletin officiel des lois et arrêtés royaux de la Belgique*". But for those who thought that such a bilingual official journal was typically Belgian, Malta proves them wrong! Of course, in Malta, the languages are not the same: in those years, the Malta Government Gazette was published in English and Italian. And it's interesting to see that it contains more than only official notices of the Maltese government. On the 10th of August for example, it gives some news from Belgium and the arrival of Prince Leopold of Saxe-Coburg in Ostend, as King of the Belgians. In the same issue, there is also news about a dangerous pandemic, spreading all over the world: the cholera morbus. Therefore, it was decided to impose a quarantine to ships coming from the North of Europe. But if we are consulting the Malta Gazette, it is because it gives some interesting news about the new volcano nearby.

Besides the open question about who saw the smoke first: On the 13th July, the column of smoke could be seen from the people in Sciacca[14]. It was at some 30 miles off the coast, in a place called "secca di mare", which is a bank below sea level. First, they thought it was a steam boat, but as it persisted, they thought it might be a burning steam boat[15]. On the same day, 2 ships were closer to the smoke: Prospero Schiaffino on the Sant'Anna (from Sardinia) and Mario Provenzano on the Madonna delle Grazie (from Naples) reported 3 columns of smoke[16].

Some days later, the eruption really started. Captain Rossignaud (on the brig *Adelaide* from London) seems to have been the first to see "a body of fire which shot up perpendicularly to the height of a mast-head of a line of battle ship[17]".

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14 Hoffmann, *op.cit*. (n.1), p. 73.

15 Mazzarella, *op.cit* (n.1), p.92.

16 Malta Government Gazette, Wednesday 20 July 1831 (n° 1068), p.220.

17 See Malta Government Gazette, Wednesday 20 July 1831 (n° 1068), p.220 and Wednesday 27 July 1831 (n° 1069), p.227.

And in very little time, a small island emerged from the sea. Commander Charles Henry Swinburne (on the HMS Rapid) reports to Vice-Admiral Henry Hotham (Commander-in-Chief in the Mediterranean): "(...) At daylight I again steered towards it, and about 5 A.M. when the smoke had for a moment cleared away at the base, I saw a small hillock of a dark colour a few feet above the sea. This was soon hidden again, and was only visible through the smoke at the intervals between the more violent eruptions (...)"[18].

The sanitary deputation of Sciacca is said to have sent a fishing boat under the command of Michele Fiorini, who planted an oar on the shore of the new-born island. Actually, this story is rather unlikely, as in those days, the volcano was still very active. It has probably been invented by the Neapolitans afterwards, so they could pretend they had been the first finders of the new island… and certainly before the British[19].

But this extraordinary eruption interested more than only Italians (in a broad sense) and Brits. Some German professors who were present in Sicily in those days, decided to go to Sciacca to see the phenomenon with their own eyes[20]. Friedrich Hoffmann, a geologist and volcanologist, and his colleagues arrived in Sciacca on the 20th July. They hired a small boat to approach the newly formed and still smoking island[21]. They approached enough to be able to measure it, but landing was still impossible. The danger was too big[22].

The eruption stayed strong until the 24th July and then diminished until it ended completely at the beginning of August. At this time, the island reached its maximum size: 4800 meters of circumference and 63 meters high.

The news of this new island caused great interest, in particular from the British side, for whom it was located on the sea route to Malta. The Malta Government Gazette[23] reported on the 10th August that the captain Humphrey Le Fleming Senhouse raised the English flag on the island already on the 2nd August[24]. The British called the island "Graham" in honour of a

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[18] Malta Government Gazette, Wednesday 27 July 1831 (n° 1069), p.228.

[19] Mazzarella, *op.cit* (n.1), p.150-151.

[20] Hoffmann, *op.cit*. (n.1), p. 74.

[21] Hoffmann, *op.cit*. (n.1), p. 75.

[22] Hoffmann, *op.cit*. (n.1), p. 77.

[23] Malta Government Gazette, Wednesday 10 August 1831 (n° 1071), p.243-244.This Gazette was bilingual and published in both English and Italian. The Italian version of the article has been republished by Gemmellaro (*op.cit.* fn.1, p.XXIII-XXIV).

[24] Mazzarella, *op.cit* (n.1), p.149-150; Hoffmann, (*op.cit*. fn.18) p.79, 98; Malta Government Gazette, Wednesday 10 August 1831 (n° 1071), p.243.

First Lord of Admiralty (1830-1834)[25]. But this story is also very questionable, because the 2nd August too is before the end of the eruption[26].

Friedrich Hoffmann[27] seems to doubt it. He tried to access the new island but renounced because it was too difficult. In his report to the Prussian Academy, he writes that the people from Sciacca dared to go on the island for the first time on 25 August only, because only then, the volcanic activity had calmed down.

The French Professor Constant Prévost[28] doesn't say anything else, when he writes that on 12 August, the eruptions were still so strong that it was impossible for Professor Gemmellaro to even approach the island.

Carlo Gemmellaro[29] himself, writes that he was surprised to read that Senhouse landed on the island and found it so firm and compact that in his opinion, a permanent island was born. Gemmellaro actually writes that Senhouse was bragging about planting the English flag there, which nobody saw waving nine days later. Gemmellaro also reports that there was other news about the volcano, from which it appears that on 20th August the surgeon Hosborne of the ship Ganges with other officers coming from Malta disembarked on the island, and went up the hill, where, it is said, Sir Coleman planted the English flag.

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25 Mazzarella, *op.cit* (n.1), p.158-159.

26 Mazzarella, *op.cit* (n.1), p.162-163.

27 Hoffmann, *op.cit*. (n.1), p.81: "Am 25. August endlich wagten erst zuerst einige Sicilianer aus Sciacca in Gesellschaft eines Engländers (Namens John Wright) einen Ausflug nach der ruhig gewordenen Feueresse zu machen (...)".

28 Prévost, Notes *op.cit*. (n.1), p.98: "Cependant, le 12 du même mois, le professeur Gemmellaro fut témoin d'éruptions dont la force l'empêcha même d'approcher, ce qui prouve des intermittences dans les phénomènes et atteste que des crises violentes ont souvent été séparées par des intervalles de repos.

29 Gemmellaro, *op.cit*. (n.1), p.19: "Si legge però nella Gazzetta di Malta (N° 1071. Wensday 10 august), che il cap. Senhouse col cutter inglese *Hind*, nel giorno 2 agosto si portò a verificare questo straordinario fenomeno (...). Ma quel che più mi sorprende si è ch'egli approdò al nuovo Vulcano, e lo trovò di terreno tanto sodo, che lo chiamò un'isola permanente, quando non è che un ammasso di ceneri e scorie leggiere: si vanta avervi piantata la bandiera inglese, che nessuno di noi vide sventolare nove giorni dopo, e volle dare alla stessa il nome *Graham"*. Gemmellaro also reports (p.44): "Dacchè fu letta questa Relazione, sino al giorno in cui se n'è cominciata la stampa, si sono avute altre notizie intorno al Vulcano, dalle quali risulta che il dì 20 agosto il chirurgo Hosborne del Ganges con altri uffiziali venuti da Malta vi sbarcarono, e salirono sulla collina, ove, si dice, aver piantata la bandiera inglese il sig. Coleman. Il diametro del cratere si trovò di 90 piedi circa: esso vedevasi ripieno d'acqua rossastra tinta di perossido di ferro in soluzione, e fortemente salata: la sua temperatura era di gr. 190 Far. L'eruzione pareva esser cessata sin dal giorno precedente. L'isola consisteva di un ammasso di scorie e cenere; la sua circonferenza estendevasi ad un miglio circa, e l'altezza a 160 piedi".

On the 17th August, Ferdinand II of Bourbon, King of Naples and Sicily included the island in its Kingdom[30] under the name of Ferdinandea[31]. But he did so without any factual measure of taking possession. The symbolic and dubious action of Fiorini cannot be considered as the start of an official occupation for the Kingdom.

On the 25th of September, Friedrich Hoffmann and his colleagues tried to approach the island again. They were encouraged to do so by the numerous stories of people who landed on the island successfully[32]! They noticed how much it had changed since their first visit two months earlier. They approached the island enough to touch it with the oars, but were again unable to land. The waves and the muddy and very lose sand made it impossible[33].

Another interesting source of information is the report written by Professor Constant Prévost, who was sent by the French Academy of Sciences[34].

On the 28th September, the French expedition was experiencing the same problems as the Germans: it was impossible to land on the island[35]. But then a seaman offered to swim to it[36]. Even though he reached the shore without being harmed, he made signs, showing that to soil was so hot, that he could barely stand on it.

On the 29th September, they tried again and were able to land with their boat this time. Frenchman Derussat, who was part of a scientific expe-

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30 Mazzarella, *op.cit* (n.1), p.163.

31 This name has been proposed by Carlo Gemmellaro, geologist at the university of Catania who was amongst the first to study the volcano. Mazzarella, *op.cit* (n.1), p.156-157. But in his book, Gemmellaro (p.46) writes precisely that he will call it "*Isola di Ferdinando II*". The name has been changed to "*Ferdinandea*" in the decree of the King.

32 Hoffmann, *op.cit*. (n.1), p. 82-83.

33 Hoffmann, *op.cit*. (n.1), p. 83: „Ein heftiger Scirocco, welcher bereits in der Nacht uns einige mühselige Schifffahrt veranlaßt hatte, nöthigte uns bald, vorsichtig fortrudernd, unter der Nordwestspitze des Vulcans eine Zuflucht zu suchen, und wir näherten uns derselben, bis wir mit den Rudern in den Sand stießen. Sehr bald aber überzeugten uns die mehrfach vergeblich wiederholten Versuche unserer gutwilligen und furchtlosen Matrosen, daß es unmöglich sey, des unruhigen Meeres und des aufgelockerten schlammigen Sandes wegen, der den Grund bildete, hier landen zu können, und wir mußten uns daher mit der Anschauung dessen begnügen, was die sehr grobe Nähe aus der Barke uns zu beobachten gestattete".

34 Constant Prévost, "Notes sur l'île Julia : pour servir à l'histoire de la formation des îles volcaniques", in Mémoires de la Société Géologique de France, 1835, p.91-124;

35 Constant Prévost, "Description de l'ile volcanique sortie récemment au sein de la Méditerranée", in Nouvelles annales des voyages, de la géographie et de l'histoire 1831, p. 292 : "Les marins pensèrent d'un commun accord qu'il y aurait imprudence à tenter le débarquement dans ce moment, et qu'inévitablement l'embarcation chavirerait".

36 Constant Prévost, "Extrait d'une Lettre de M. Constant Prévost, datée de Malte le 3 octobre 1831, et adressée à l'académie des Sciences, sur le nouvel Islot volcanique de la mer de Sicile", in Annales des sciences naturelles 1831, p. 106-107 ; Idem, Nouvelles Annales op. cit. n.36, p. 293.

dition under leading of Professor Prévost, planted the French flag on the highest spot of the island[37]. Prévost also wrote a plate[38] he planted on the island, giving the name "Julia", as it rose during the month of July. Prévost writes that when he decided to call the island "Julia", it was because he was not aware of the fact that it had previously been called Graham and that the British flag had been raised on it earlier[39].

In the end, the island received at least 7 names: Ferdinandea, Proserpina, Corrao, Graham, Hotham, Julia, Nerita[40].

The dispute seems to have involved mainly Great Britain and the Kingdom of the Two Sicilies[41]. Even if the French raised their flag on the island just like the British, apparently, they didn't do it for the same purpose. The French wanted to show their scientific interest for the volcano, but not to occupy the island, which they thought to be ridiculous, certainly now it had become clear that the island would not last long anymore[42]. Being theoretically neutral on this topic, Hoffmann[43] raised doubts about the right of the English to take possession of an island which had apparently risen from the waters of the Kingdom of the Two Sicilies.

But while the states were arguing about the ownership of the new island, it was being washed away by the tides and waves, becoming smaller and smaller. When Friedrich Hoffmann visited the island (on 26 September 1831), without being able to land because of the too strong winds[44], he noticed that the winter would probably suffice to make an end to the island's existence[45]. When the French visited it a few days later, the circumference had already diminished from 4600 meters to only 700 meters[46].

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37 Mazzarella, *op.cit* (n.1), p.180-186.
38 Constant Prévost, Nouvelles Annales (op.cit), p. 295 : "ILE JULIA
39 Mazzarella, *op.cit* (n.1), p.159. Constant Prévost, Notes *op.cit.*, (n.1), p.98: "C'est le 2 août que le capitaine Senhouse, commandant le vaisseau vice-amiral le Saint-Vincent, débarqua pour la première fois, et qu'il put faire planter la bannière anglaise sur cette île encore naissante à laquelle il donna le nom de Graham, circonstance que nous ignorions, le 29 septembre, lorsque nous descendimes sur ce même sol, que nous appelâmes île Julia".
40 About the different names of the island, see Mazzarella, *op.cit* (n.1), p.156-160. Hoffmann (*op.cit*. fn.18, p.97-98) mentioned only 6 names, leaving out "Proserpina".
41 Mazzarella, *op.cit* (n.1), p.163-168.
42 Constant Prévost, "Descente à l'Ile Julie, nouvellement sortie de la mer sur les côtes de Sicile" in *Revue des deux mondes* 1831, T.4, p. 393-405, p.400-401; also Mazzarella, *op.cit* (n.1), p.184-186.
43 Hoffmann, *op.cit*. (n.1), p.98.
44 Hoffmann, *op.cit*. (n.1), p.86.
45 Hoffmann, *op.cit.* (n.1), p.87.
46 Mazzarella, *op.cit* (n.1), p.182; Prévost, (Notes *op.cit.*, n.1, p.100).

In November, another prominent visitor wanted to see the new island, and this was Sir Walter Scott, the famous Scottish writer. When he visited[47] the island, it emerged only of a few meters[48].

This is what Walter Scott writes to his friend Skene[49] about the island:

> "As it has been my lot to see the new volcano, called Graham's Island, either employed in establishing itself, or more likely in decomposing itself–and as it must be an object of much curiosity to many of our brethren of the Royal Society, I have taken it into my head that even the very imperfect account which I can give of a matter of this extraordinary kind may be in some degree valued. Not being able to borrow your fingers, those of the Captain's clerk have been put in requisition for the enclosed sketch, and the notes adjoined are as accurate as can be expected from a hurried visit. You have a view of the island, very much as it shows at present, but nothing is more certain than that it is on the eve of a very important change, though in what respect is doubtful. I saw a portion of about five or six feet in height give way under the feet of one of our companions on the very ridge of the southern corner, and become completely annihilated, giving us some anxiety for the fate of our friend, till the dust and confusion of the dispersed pinnacle had subsided. You know my old talents for horsemanship. Finding the earth, or what seemed a substitute for it, sink at every step up to the knee, so as to make walking for an infirm and heavy man nearly impossible, I mounted the shoulders of an able and willing seaman, and by dint of his exertions rode nearly to the top of the island. I would have given a great deal for you, my friend, the frequent and willing supplier of my defects; but on this journey, though undertaken late in life, I have found, from the benevolence of my companions, that when one man's strength was insufficient to supply my deficiencies, I had the willing aid of twenty if it could be useful. I have sent you one of the largest blocks of lava which I could find on the islet, though small pieces are innumerable. We found two dolphins, killed apparently by the hot temperature, and the body of a robin redbreast, which seemingly had come off from the nearest land, and starved to death on the islet, where it had neither found food nor water. Such had been the fate of the first at-

47 When Sir Walter Scott visited the island, on 22 November 1831, he was already 60 and rather ill (he eventually died some 10 months later). Because of his illness, he wasn't able to walk on the island alone.

48 Mazzarella, *op.cit* (n.1), p.191-194.

49 Sir Walter Scott, "Letter to Mr. James Skene", *op.cit* (n.1).

tempt to stock the island with fish and fowl. On the south side the volcanic principle was still apparently active. The perpetual bubbling up from the bottom produces a quantity of steam, which rises all around the base of the island, and surrounds it as with a cloak when seen from a distance. Most of these appearances struck the other gentlemen, I believe, as well as myself; but a gentleman who has visited the rock repeatedly, is of opinion that it is certainly increasing in magnitude. Its decrease in height may be consistent with the increase of its more level parts, and even its general appearance above water; for the ruins which crumble down from the top, are like to remain at the bottom of the ridge of the rock, add to the general size of the islet, and tend to give the ground firmness.

The gales of this new-born island are anything but odoriferous. Brimstone, and such like, are the prevailing savours, to a degree almost suffocating. Every hole dug in the sand is filled with boiling water, or what was nearly such. I cannot help thinking that the great ebullition in the bay, is the remains of the original crater, now almost filled up, yet still showing that some extraordinary operations are going on in the subterranean regions.

If you think, my dear Skene, that any of these trifling particulars concerning this islet can interest our friends, you are free to communicate them either to the Society or to the Club, as you judge most proper. I have just seen James [James Henry Skene, Esq., a son of Sir W.'s correspondent, was then a young officer on duty at Malta.] in full health, but he vanished like a guilty thing, when, forgetting that I was a contraband commodity, I went to shake him by the hand, which would have cost him ten days' imprisonment, I being at present in quarantine. We saw an instance of the strictness with which this law is observed: In entering the harbour, a seaman was pushed from our yard-arm. He swam strongly, notwithstanding the fall, but the Maltese boats, of whom there were several, tacked from him, to avoid picking him up, and an English boat, which did take the poor man in, was condemned to ten days' imprisonment, to reward the benevolence of the action."

Sir Walter Scott was certainly right about the fact that the island was decomposing itself. Indeed, in December the volcano was completely under water again[50].

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50 According to one source at least [Mazzarella, *op.cit* (n.1), p.196] but Prévost writes that the island disappeared only on 12 January 1832 (Mazzarella, *op.cit* (n.1), p.201).

It reemerged in 1863 for a few days only[51]. In 1987, during the war between the USA and Libya, it seems that an American warplane took the island for a submarine and dropped depth charges on it[52].

2. Ferdinandea today

The old dispute about the island had a new episode in 2000, with an article written by Richard Owen, of the Times. The title of his article "British isle rises off the coasts of Sicily" was clear enough[53]! The seismic activity in the area allowed it to think that the island could rise again soon. But the diplomatic question was still open. Who will own this island if it rises again? For now, nature has decided to delay the case, but you can bet that the Italians did not like the article in the Times!

One thing is certain: the island would be outside of the territorial waters of Italy because it is at a distance of 22 miles from the closest Sicilian shore. Scientist say that the island could rise again but it is actually impossible to predict precisely. It seems to be now at ca. 5-10 meters below the sea level. The cone of the volcano starts at 190 meters below sea level. The area has long been known as being dangerous. It is the meeting point of the African and the Eurasian tectonic plates. The Earth crust there is very thin, which favours the exit of magma. To the difference of the Etna, there is no magma room, where magma can accumulate before the eruption. Therefore, there is no way to anticipate it.

It might be useful to remind that such an eruption is not precisely something to look forward to, as these eruptions can be devastating! It seems that an eruption in this area caused a tsunami right there and devastated the Greek city of Selinunte.

Never mind this… What if the island rises again? Probably at least the British and the Italians would claim the island as theirs. But who would prevail legally?

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51 Mazzarella, *op.cit* (n.1), p.207.

52 This is what Richard Owen writes in the newspaper Times, in both his articles about Graham/Ferdinandea ("British isle rises off Sicily coast" 5 February 2000 and "Italy stakes early claim to submerged Island" 27 November 2002). In the first of these articles, the author refers to "diplomats" about this story. When asked about this in 2020, Richard Owen kindly replied to my questions, but did not remember precisely how he got the information.

53 See previous footnote.

Obviously, it is impossible to own an island that does not exist as it does not conform to the definition of an island[54]. Following the International Convention of Montego Bay (1982), the territorial sea cannot exceed 12 miles[55]. This means that the Graham Shoal or Bank is outside of the Italian territorial sea[56]. Thus: International law does not help us immediately in this case. The bank has no owner and if it emerges again, it will not be automatically included in the Italian territory.

No reference is made to the acquisition of new territories in the treaty itself, but there have been some cases decided by international arbitration using the concept of effective occupation of a land[57]. These rules about occupation have been immediately inspired from Roman Law like so many other rules of international law[58]. The next step I suggest is therefore to go back to these rules to see if they help us understand – and eventually solve – our problem.

3. Introduction to the Roman Law of Occupatio

As it is very well known, the *occupatio* allows to acquire things that don't belong to anyone, are the property of no one. Before becoming a legal institution, it was merely a factual mode of acquisition. It probably was chronologically the first way to acquire ownership on something. From a dogmatic point of view, it probably happened as follows: A man would become owner of the things he takes[59]. And he would do this simply by taking

54 UN Convention on the Law of the Sea (Montego Bay 1982), Article 121: *Regime of islands*.1: An island is a naturally formed area of land, surrounded by water, which is above water at high tide. (…).

55 Article 3: *Breadth of the territorial sea*. Every State has the right to establish the breadth of its territorial sea up to a limit not exceeding 12 nautical miles, measured from baselines determined in accordance with this Convention.

56 It would be possible for Italy to consider the Graham Shoal zone as a Contiguous Zone (UN Convention on the Law of Sea, Article 33: 1. In a zone contiguous to its territorial sea, described as the contiguous zone, the coastal State may exercise the control necessary to: (a) prevent infringement of its customs, fiscal, immigration or sanitary laws and regulations within its territory or territorial sea; (b) punish infringement of the above laws and regulations committed within its territory or territorial sea. 2. The contiguous zone may not extend beyond 24 nautical miles from the baselines from which the breadth of the territorial sea is measured.) However, I don't think this implies that the island would automatically become Italian, if it were to emerge again.

57 See the Island of Palmas case (or Miangas), *United States of America vs The Netherlands*, The Hague 4 April 1928, or the Clipperton Island case, *Mexico vs France*, The Hague 28 January 1931.

58 See Randall Lesaffer, "Argument from Roman Law in Current International Law: Occupation and Acquisitive Prescription", The European Journal of International Law 16/1 (2005), p.25-58.

59 Therefore, *occupatio* is considered to be a *ius gentium* rule. Inst.Just. 2.1.11-12. Max Kaser, *v° occupatio*, in RE, Supplementband VII, 1940, 682. Cicero expressed a similar idea in his *de Off.* 1.21.

a factual possession of that thing. Nowadays, *occupare* means taking autonomously possession of a thing with no owner[60]. It is surprising to notice that the word "*occupatio*" is present in the Roman legal sources only with the meaning "what you are busy with", but never our legal term, meaning a way to take possession of a thing with the scope of acquiring ownership[61]. Therefore, the Roman jurists only used the verb "*occupare/occupo*". Things without an owner were called *res nullius* or, if they had been abandoned by their owner: *res derelictae*. Taking possession was meant to be merely factual. The sources don't speak of the will of he who is occupying. Probably this will didn't have to be precise. The occupier did not have to know whether the thing was a *res nullius* or a *res derelicta*. We can derive this from the fact that if someone wanted to steal a thing, not knowing that the owner of that thing had actually abandoned it, did not commit any theft.

> Ulp. (41 Sab.) D. 47.2.43.5:
> *Quod si dominus id dereliquit, furtum non fit eius, etiamsi ego furandi animum habuero: Nec enim furtum fit, nisi sit cui fiat: in proposito autem nulli fit, quippe cum placeat Sabini et Cassii sententia existimantium statim nostram esse desinere rem, quam derelinquimus*.
> If its owner has abandoned something, I will not commit theft of it, even though I take it with theftuous intent; for there can be no theft without an owner of the object; in the case posited, the thing belongs to no one; for the view of Sabinus and Cassius has commended itself that a thing ceases to be ours as soon as we abandon it[62].

So, it is not possible to commit a theft on a thing that has actually been abandoned by its owner… which means that the will of he who takes possession of the thing does not matter.

Like very often in Roman law, the sources show a very casuistic panorama of the institution of *occupatio*. There are 7 groups of cases, depending of

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[60] Not any *res nullius* can be object of an *occupatio*. The *res nullius hereditariae*, need to be excluded here. Even though they belong to nobody, they cannot be acquired by *occupatio*.

[61] The authors of the VIR (*vocabularium iurisprudentiae romanae*) forgot the word "*occupatio*" which made Max Kaser write (op.cit. fn.59) that it was totally absent of the sources, but as the Heumann-Seckel dictionary puts it better, it is in the sources, but always with the meaning of activity, what keeps you occupied or busy. It is never used in the meaning of an acquisition mode. See Heumann-Seckel, Handlexikon zu den Quellen des römischen Rechts[10], Graz 1958, s.v. *occupatio* (p.386). There is at least one text that comes close to use the word *occupatio* with the meaning of acquiring ground, but it is more a historical thought than a text about the legal institution (Cic.*Off.*1.21).

[62] All English translations of fragments from Justinian's Digest are taken from Alan Watson's edition, Philadelphia 1985. Book 47 has been translated by J.A.C. Thomas.

the object that is occupied. So, we have: (1.) Wild animals, (2.) Islands rising from the sea, (3.) Spoils of war, (4.) Constructions on beaches, (5.) Precious stones or gems found on beaches, (6.) Abandoned things and (7.) Discovered treasures.

In this article, I will consider the 2 first categories.

4. Occupatio in Gaius' writings

The figure of the great jurist Gaius is central in the field of *occupatio* and *res nullius*. Most of the texts transmitted to us are attributed to him. To begin with, Gaius writes that ownership can be acquired *iure civili* or *iure naturali*[63]. Civil acquisition is possible only by Roman citizen but anyone can acquire by natural law. Amongst natural modes of acquisition, Gaius cites *traditio* and *occupatio*[64]. He writes that through *occupatio*, we can become owner of a thing that did not belong to anyone before. So, a *res nullius* can be acquired by occupying it[65]. But what are the things included in the category of *res nullius*? Gaius writes[66] that they are the animals you can catch on earth, in the sea or in the sky.

For the Romans, there were 2 types of animals: Wild animals and domestic animals. Domestic animals were never considered *res nullius* and therefore could not be acquired by *occupatio*.

63 Gai.2.65: *Ergo ex his, quae diximus, apparet quaedam naturali iure alienari, qualia sunt ea, quae traditione alienantur, quaedam civili: nam mancipationis et in iure cessionis et usucapionis ius proprium est civium romanorum*. 66. *Nec tamen ea tantum, quae traditione nostra fiunt, naturali nobis ratione adquiruntur, sed etiam quae occupando ideo consequi poterimus (?), quia antea nullius essent, qualia sunt omnia, quae terra mari caelo capiuntur*. Translation by W.M.Gordon/O.F.Robinson: 65. And so it is apparent from what we have said that some forms of alienation fall under the law of nature, for example, alienation by delivery, and some fall under state law. For the right to use mancipation, assignment in court and usucapion is specific to Roman citizens. 66. But it is not only by delivery that we acquire things which we get by first taking and which becomes ours because previously they belonged to no one, for example, everything caught on land, in the sea or in the sky. On this opposition between civil law and natural law, see e.g.: Mario Talamanca, *Istituzioni di diritto romano*, Milano 1990, 413.

64 Gai.2.65 (see previous fn.).

65 In addition to Gai.2.66 (fn.63) there is also a fragment of the Digest, written by the same Gaius (2 rer. cott.) D.41.1.3pr.: *Quod enim nullius est, id ratione naturali occupanti conceditur*. Translation A.Watson/JA.C.Thomas: What presently belongs to no one becomes by natural reason the property of the first taker.

66 Again in Gai.2.66 (see fn.63).

4.1. Occupatio of animals

Amongst the wild animals, the Romans made another distinction between domesticated animals and the others. The domesticated animals remained our property as long as they had the *animus revertendi*, which is the habit to come back[67]. The others would remain our property only as long as we have them under our *custodia* or custody. By losing *animus revertendi* or escaping from our *custodia*, the animal would recover its natural liberty and be a *res nullius* again, so it could again be acquired by anyone who occupied it. These distinctions are to be found in another text of Gaius:

> Gaius*, Institutes,* 67-68:
> *67. Itaque si feram bestiam aut volucrem aut piscem ceperimus, quidquid (?) captum fuerit, id nostrum esse incipit (?) et eo usque nostrum esse intellegitur, donec nostra custodia coerceatur. cum vero custodiam nostram evaserit et in naturalem se libertatem receperit, rursus occupantis fit, quia nostrum esse desinit; naturalem autem libertatem recipere videtur, cum aut oculos nostros evaserit, aut licet in conspectu sit nostro, difficilis tamen eius persecutio sit. 68. In iis autem animalibus, quae ex consuetudine abire et redire solent, veluti columbis et apibus, item cervis qui in silvas ire et redire solent, talem habemus regulam traditam, ut si revertendi animum habere desierint, etiam nostra esse desinant et fiant occupantium; revertendi autem animum videntur desinere habere, cum revertendi consuetudinem deseruerint*.
> (67) And so, if we catch a wild animal or bird or fish it becomes ours as soon as we have caught it and it remains ours so long as we keep it under our control. If it escapes our control and recovers its natural liberty the next taker can have it because it ceases to be ours. It is thought to have regained its natural freedom when it has gone out of our sight or when, though still in sight, it is difficult to reach it. (68) However, in the case of those animals which regularly come and go, such as pigeons and bees and also deer which go back and forth to the woods, we have this rule handed down: if they lose their homing instinct, then they stop being ours. They then vest in the next taker. They are judged to lose the homing instinct when they stop coming back[68].

67 On this habit to come back, see e.g.: Johanna Filip-Fröschl, "*Cervi qui in silvas ire et redire solent*. Anmerkungen zu einem *exemplum iuris*", in FS Mayer-Maly, Köln 2002, pp.191-213; Mariko Igimi, "*Occupatio* im Alltag der Römer", in: Aus der Werkstatt römischer Juristen, Berlin 2016, pp.153-171.

68 Translated by W.M.Gordon/O.F.Robinson.

We can also read this rule in another fragment of Gaius:

> Gai. (2 rer. cott.) D.41.1.3.2:
> *Quidquid autem eorum ceperimus, eo usque nostrum esse intellegitur, donec nostra custodia coercetur: Cum vero evaserit custodiam nostram et in naturalem libertatem se receperit, nostrum esse desinit et rursus occupantis fit.*
> Any of these things which we take, however, are regarded as ours for so long as they are governed by our control. But when they escape from our custody and return to their natural state of freedom, they cease to be ours and are again open to the first taker[69].

The rule is thus: If one loses the *potestas* on the wild animal, one also loses the ownership and thus the animal itself. The concept of *potestas* in this context is to be found in a fragment of Proculus[70]. To summarise the case: there is a boar caught in a snare and someone, who walks by, liberates the boar. The question is then whether the hunter was already the owner of the boar and whether he had an action against the guy (the walker) who liberated the boar.

Proculus makes a series of distinctions: Did the walker simply liberate the boar or did he take it back with him? Was the snare located in a public or in a private place? If it was in a private place, was it owned by the hunter or by a third person? If it was owned by a third person, did he authorise the hunter to hunt there? And then, was the boar trapped in the snare in a way that it couldn't escape, or would it have been able to escape on its own after a longer struggle?

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69 Translated by A.Watson/J.A.C.Thomas.

70 Proculus (2 epist.) D.41.1.55: *In laqueum quem venandi causa posueras, aper incidit, cum eo haereret, exemptum eum abstuli. Num tibi videor tuum aprum abstulisse? Et si tuum putas fuisse, si solutum eum in sylvam dimisissem, eo casu tuus esse desisset, an maneret? Et quam actionem mecum, haberes, si desisset tuus esse: num in factum dari oporteret, quaero? Respondit: Laqueum videamus, ne intersit in publico an in privato posuerim: et si in privato posui, utrum in eo ila haeserit aper, ut experdire se non possit ipse: an diutus liclando expediturus se fuerit. Summam famen hanc puto esse, ut si in meam potestatem pervenit, meus factus sit. Sin autem aprum meum ferum in suam naturalem laxitatem dimisisses, eo facto meus esse desisset, et actionem mihi in factum dari oportere: veluti responsum est, cum quidam poculum alterius ex nave ejecisset*. Translation by A.Watson/J.A.C.Thomas: A wild boar fell into a trap which you had set for such purpose, and when he was caught in it, I released him and carried him off. Am I, then to be seen as stealing your boar? And supposing him to be yours, would he cease to be or remain your property if, having released him, I set him free in a wood? Again, if he ceased to be yours, what action would you have against me? Should it be an action in factum? These are my questions. The answer was this: Let us consider whether the boar was so caught that he could not extricate himself or could do so only by lengthy struggling. Still I think that the cardinal rule is that if he has come into my power, the boar has become mine. And if you release my boar into his natural state of freedom and thereby he ceased to be mine, I should be given an action in factum, as was the opinion given when someone threw another's cup from a ship.

Our problem of interpretation in this fragment[71], is that Proculus answers all these questions simply with the words: "*si in meam potestatem pervenit, meus factus sit*". If it ended in my power, it'd be mine!

And so? Does it mean that the distinctions Proculus made are useless? Some scholars think so but I doubt that because I wouldn't understand why Proculus would fuss with us. For me, the *potestas*, just like the *occupatio*, is a question of facts. To know if the hunter had sufficient *potestas* over the boar, we must check if he could easily access to the snare again.

I consider thus, that in the eyes of Proculus, the hunter could potentially become owner of the boar by the sole fact that it fell in the trap, because otherwise the famous jurist would have fooled us with useless talk.

We already know how the hunter lost the ownership on the boar: when it is freed, it turns to be a *res nullius*, because it has no *animus revertendi* and it has never been domesticated anyway. Proculus gives an *actio in factum* to the hunter in this case. And if the walker took the boar with him, then the hunter would have had an *actio furti* (action for theft) against him.

But what does interest us most here, is that Proculus says that the acquisition of the boar is a question of *potestas*.

There has been a controversy on the analysis of this *potestas*. Romans jurists wondered whether there was enough *potestas* on a wild animal when it was just wounded by the hunter or when the hunter was merely chasing it. Gaius (2 rer. cott., D.41.1.5.1[72]) who probably represents the dominant position on this, writes that it is not enough to wound the animal, but that

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[71] An extended version of my interpretation can be read here: Jean-François Gerkens, *Aeque perituris…une approche de la causalité dépassante en droit romain Classique*. Liège 1997, 121-152 (http://hdl.handle.net/2268/57929). More recently, see also: Francesco Musumeci, "Proc. 2 *epist.* D.41.1.55: su un caso particolare di danno sanzionato con un'*actio in factum*", in E.Chevreau etc. (Ed.), Carmina Iuris. Mélanges en l'honneur de Michel Humbert. Paris 2012, pp. 585-598.

[72] Gaius (2 rer.cott.) D.41.1.5.1 : *Illud quaesitum est, an fera bestia, quae ita vulnerata sit, ut capi possit, statim nostra esse intellegatur. Trebatio placuit statim nostram esse et eo usque nostram videri, donec eam persequamur, quod si desierimus eam persequi, desinere nostram esse et rursus fieri occupantis: itaque si per hoc tempus, quo eam persequimur, alius eam ceperit eo animo, ut ipse lucrifaceret, furtum videri nobis eum commisisse. Plerique non aliter putaverunt eam nostram esse, quam si eam ceperimus, quia multa accidere possunt, ut eam non capiamus: quod verius est.* Translation by A.Watson/J.A.C.Thomas : The question has been asked whether a wild animal, so wounded that it may be captured, is already ours. Trebatius approved the view that it becomes ours at once and that it is ours so long as we chase after it; but, if we abandon the chase, it ceases to be ours and is open to the first taker. Hence, if, during the period of our pursuit, someone else should take the animal, with the intent to profit thereby, he is to be regarded as stealing from us. The majority opinion was that the beast is ours only if we have captured it because many circumstances can prevent our actually seizing it. And that is the sounder opinion.

you need to hold it, because until then, many things can happen (*quia multa accidere possunt*).

But in my opinion, we need to distinguish between animals the hunter wants to catch alive or dead. For animals he intends to catch alive, it might be difficult to hold it with his hands anyway (it would certainly be, if we imagine a living wild boar!). Therefore, Proculus' text seems to allow us to admit that for this kind of hunt, the hunter could become owner since the moment in which the animal is caught in the trap.

After this brief overview of the Roman solutions for the acquisition of property on wild animals, we can proceed to the case that is our primary concern: the acquisition by occupation of islands emerging out of the sea.

4.2. Occupatio of islands rising from the sea (insula in mari nata)

Actually, for the islands rising from the sea, the rule is the same as for the wild animals. Gaius writes that, because they have never been owned by nobody, the rule is clear: "*occupantis fit*!": they belong to the first person who occupies it:

> Gai. (2 rer. cott.) D.41.1.7.3:
> *Insula quae in mari nascitur (quod raro accidit) occupantis fit: nullius enim esse creditur. in flumine nata (quod frequenter accidit), si quidem mediam partem fluminis tenet, communis est eorum, qui ab utraque parte fluminis prope ripam praedia possident, pro modo latitudinis cuiusque praedii, quae latitudo prope ripam sit: quod si alteri parti proximior sit, eorum est tantum, qui ab ea parte prope ripam praedia possident.*
> An island arising from the sea (a rare occurence) belongs to the first taker, for it is held to belong to no one. An island arising in a river (a frequent occurrence), if indeed it appears in the midstream of the river, is the common property of those who have holdings on either bank of the river to the extent that those holdings follow the bank; but if it lies to one side of the river rather than the other, it belongs only to those who have holdings on that bank[73].

[73] Translation by A.Watson/J.A.C.Thomas.

But Gaius writes that it rarely happens to have an island rising from the sea. It happens more frequently in rivers. But for islands formed in rivers, the acquisition happens over *occupatio* only for *agri limitati*, this means acres measured by *agrimensores*[74]. In other cases, the islands formed in rivers belong to the owners of the river banks.

Anyway, for the case of the islands rising in the sea, Gaius writes that it rarely happens and therefore, he has no case law, no examples to offer. Then again: 'rarely' does not mean 'never'. During the antiquity, the cases of the Aeolian islands (North of Sicily) were well known and the great Aristotle has written about them[75]. The absence of case law about those islands was no big deal for Gaius I guess, as the legal issue didn't seem complicated.

5. The Roman Law of occupatio applied to the case

As far as I know, Roman jurists did never address this problem directly. We saw that Gaius (2 rer. cott. D.41.1.7.3[76]) writes that it rarely occurs to

74 Ulp. (68 ed.) D. 43.12.1.6: *Si insula in publico flumine fuerit nata inque ea aliquid fiat, non videtur in publico fieri. illa enim insula aut occupantis est, si limitati agri fuerunt, aut eius cuius ripam contingit, aut, si in medio alveo nata est, eorum est qui prope utrasque ripas possident*. Translation by A.Watson/T.Braun: If an island comes into being in a public river and something is done on the island, it is not held that it is being done on public property. For the island belongs either to the person who first occupies it if the fields have fixed boundaries, or to the person whose bank it adjoins, or if it has come into being in the middle of the channel, to those who possess each bank nearby; Flor. (6 Inst.) D. 41.1.16: *In agris limitatis ius alluvionis locum non habere constat: idque et divus Pius constituit et Trebatius ait agrum, qui hostibus devictis ea condicione concessus sit, ut in civitatem veniret, habere alluvionem neque esse limitatum: agrum autem manu captum limitatum fuisse, ut sciretur, quid cuique datum esset, quid venisset, quid in publico relictum esset*. Translation by A.Watson/J.A.C.Thomas : In the case of lands measured out, it is generally agreed that the right of alluvion has no place. The deified Pius ruled to this effect and Trebatius says that land granted to defeated enemies on the condition that it becomes civic property does have the right of alluvion and is not measured out; but in the case of land taken by force it is measured out so that it might be known what was given to whom, what was sold, and what remained public property.

75 Aristotle, *Meteorology* 2.8.367.

76 Text and translation of this text (Gai. D.41.1.7.3) is above, at footnote 73. A similar rule can be found in another fragment of the Digest, written by the jurist Paul (54 ed.) D.41.2.1.1: *Dominiumque rerum ex naturali possessione coepisse Nerva filius ait eiusque rei vestigium remanere in his, quae terra mari caeloque capiuntur: nam haec protinus eorum fiunt, qui primi possessionem eorum adprehenderint. Item bello capta et insula in mari enata et gemmae lapilli margaritae in litoribus inventae eius fiunt, qui primus eorum possessionem nanctus est.* Translated by A.Watson/J.A.C.Thomas: The younger Nerva says that the ownership of those things originated in natural possession and that a relic thereof survives in the attitude to those things which are taken on land, sea, or in the air; for such things forthwith become the property of those who first take possession of them. In like manner, things captured in war, islands arising in the sea, and gems, stones, and pearls found on the seashore become the property of him who first takes possession of them.

see an island rising from the sea. So, we can easily guess what he would write about islands that rise, then sink, and then rise again several times? The only thing we know for sure, is that the island is a *res nullius* and that the first person who occupies it, owns it.

The sea itself is certainly a *res communis* (a thing common to everyone). We can read this in a fragment of Marcian:

> Marcian. (3 Inst.) D.1.8.2.pr.-1:
> *Quaedam naturali iure communia sunt omnium, quaedam universitatis, quaedam nullius, pleraque singulorum, quae variis ex causis cuique adquiruntur*. 1. *Et quidem naturali iure omnium communia sunt illa: aer, aqua profluens, et mare, et per hoc litora maris.*
> Some things belong in common to all men by *jus naturale*, some to a community corporately, some to no one, but most belong to individuals severally, being ascribed to someone on one of various grounds. 1. And indeed by natural law the following belong in common to all men: air, flowing water, and the sea, and therewith the shores of the sea[77].

And what about the sea ground? When it was far from the shore, the Romans did not consider that it was possible to own it. It was different when someone built something in the sea. Because then, he who constructed something became owner of the building. But this is of course rather different from the case of Ferdinandea, where nothing has ever been built[78].

So, I suggest we could consider if we can't find any analogy with the wild animal. So, there's my boar again!

6. Attempt of conclusion

In my opinion, it is possible to compare Ferdinandea with a wild animal that recovered its natural liberty. Indeed, the volcano that sank under the

[77] Translation by A.Watson/D.N.MacCormick.

[78] To build any construction in the sea, it was necessary to have an authorisation from the praetor, as it is written in a text of Pomponius (6 ex Plaut.) D.41.1.50pr.: *Quamvis quod in litore publico vel in mari exstruxerimus, nostrum fiat, tamen decretum praetoris adhibendum est, ut id facere liceat: immo etiam manu prohibendus est, si cum incommodo ceterorum id faciat: nam civilem eum actionem de faciendo nullam habere non dubito.* Translation by A.Watson/J.A.C.Thomas: Although what we erect on the shore or in the sea becomes ours, a decree of the praetor, nevertheless, should be obtained, authorising the erection; indeed more, one should be physically prevented, if he builds to the inconvenience of the public; for I have no doubt that he has no civil action in the matter.

sea level can't be called an island anymore. There is no doubt about this in our modern international law[79]: Ferdinandea is not an island! For this reason, the volcano cannot have any owner. Just like the wild animal that escaped from our custody. The island escaped by not being an island anymore and not being ownable by anyone.

The fact that the volcano is still the same does not change anything to it. It does not matter that the thing can still be identified. It is the same for the wild animal that was in our custody and escaped. We might recognise it, but we don't own it anymore. The only thing that counted, was that it escaped from our custody. The fact that the previous owner could recognise it in the wood had no legal consequence. If anyone else caught the animal, he would become the legal owner of it and the previous owner could do nothing against this.

An argument that could be opposed to my proposal could be that when you throw a movable thing (like a golden cup) in the sea, the owner remains the owner and does not lose ownership of the cup because he keeps the *animus domini*. Shouldn't it be the same with the island? It is true that the island is not anywhere but in a precise place, but I don't think it matters. The island is one of those things of which you lose ownership when you lose the *corpus*, the body. We can actually read this in two fragments of Paul, who cites Labeo and Nerva the younger.

> Paul. (54 ed.) D.41.2.3.17:
> *Labeo et Nerva filius responderunt desinere me possidere eum locum, quem flumen aut mare occupaverit.*
> Labeo and the younger Nerva ruled that I cease to possess land which is inundated permanently by a river or by the sea[80].
>
> Paul. (15 Sab.) D.41.2.30.3:
> *Item quod mari aut flumine occupatum sit, possidere nos desinimus, aut si is qui possidet in alterius potestatem pervenit.*
> Likewise, we cease to possess what is occupied by the sea or a river or if the person in possession should pass into the power of another[81].

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79 See fn. 54.
80 Translated by A.Watson/J.A.C.Thomas.
81 Translated by A.Watson/J.A.C.Thomas.

So, there we have another similarity between the wild animal and the island that rises from the sea: the possession of the one and the other gets lost when you lose the factual power over the animal or the island.

A supplementary argument for my analysis is that the island, just like the wild animal, is a *res nullius* in the moment when it starts to exist. You can't say the same for other *res nullius* or *derelictae*.

And yet another argument is that both the animal and the island return to their previous state of *res nullius* without the intervention of a third person, but – if I may say so – on their own. The movable thing thrown in the sea, on the contrary, has to be precisely thrown by a third person. This analogy is certainly much less accurate than the analogy with the wild animal.

Still, a wild animal is a movable thing and rather different from an island. Are we sure that we can use a rule designed for a movable thing in the case of the island? I actually don't think that it is problematic! You could pretend that there is a great difference between movable things and unmovable things, but my submission, is that our island is not any unmovable thing. One important characteristic of immovable things, is that they cannot disappear (so you can't steal them). But actually, Ferdinandea succeeded in disappearing. In general, only movable things disappear.

Today, Ferdinandea can't have any owner just like the sea ground can't have any. So, it can't even really be called an immovable thing anymore! Therefore, the analogy with wild animals is just the most accurate.

And this leads me to the only possible answer to the question I made in the beginning: Who owns Ferdinandea today? Nobody and if it rises again, it will be of the first occupier.

Of course, this solution is purely theoretical because it is not said that Roman law will be questioned or needed in case this happens. The solution is not immediately Roman either, it is inspired by Roman jurisprudence. I'm only providing an impartial legal solution based on Roman law, like the UN Convention on the Law of the Sea of Montego Bay is based on Roman law, when it defines islands and owners of islands…

Laudatio Erick Vandamme

G.Gheysen

As Proxima and as chair of the Department Biotechnology of the Faculty BioScience Engineering, it is an honor for me to introduce Prof. Em. Erick Vandamme. I first met Erick when I started at this faculty in 1993 as young professor. I got to know him as an amiable and driven person, with passion for education, university policy, science and science history.

After finishing his PhD, Erick Vandamme started in 1972 as post-doctoral researcher at Ghent University and he was professor ‘general and industrial microbiology’ from 1986 on. He became emeritus in 2008, but stayed active ever since, especially in the field of science history. He made his mark in the past 50 year on the evolution of his discipline, the industrial microbiology and biotechnology, in the field of education as well as research, at national and international level.

One of my first tasks as starting lecturer was to develop a new course on molecular biology and Erick was very helpful by providing me his own syllabi. The illustrations were eye-catching, and probably very memorable to all students of his classes, because besides the chemical formulae of amino acids and sugars, they consisted of cartoons. Those cartoons usually had little to no connection with the biochemical course content but referred to scientific concepts such as the relativity theory of Einstein. They clearly refer to Ericks general interest in science and were a pleasant intermezzo for students preparing their exam. In those times, there were no social media yet for distraction.

Prof. Erick Vandamme has an extensive bibliography of more than 500 scientific works, of which 147 in A1-journals, but also >80 chapters in books. As illustration of the type of research I show you a typical paper: it is about the use of micro-organisms for the making of useful products, and the optimalisation of those micro-organisms via mutation or biotechnology.

Additionally, he regularly gave popular lectures, accessible for a broad audience, about the scientific findings in his discipline or about the history of that research field. And this brings us to the domain of George Sarton, the history of science. Already in his early career, Prof. Erick Vandamme was fascinated by the historical development of his discipline, with -initially in Dutch- descriptions of historical aspects of biochemistry, microbiology and fermentation processes in the past centuries. Later on, he published more and more English historical scientific works in national and international scientific journals, magazines, society journals such as from the Belgian Society for Microbiology, Chemisch Weekblad, Chemistry & Industry (SCI), and in scientific standard works.

In relation to our faculty, it is important to mention that Prof. Vandamme contributed to the chronicle of the history of our faculty, including the emergence and development of scientific research at this faculty. He was chief editor of the jubilee book 1920-1995, at the occasion of the 75th anniversary of the faculty. In the recent jubilee book for the faculty centenary, he wrote a chapter about the history of agricultural education and research.

Prof. em. E. Vandamme has been involved in the activities of the Sarton-committee from the beginning and he is a representative of our faculty since 1994 till today.

By reason of aforementioned excellent scientific merits, his international impact on the discipline, his numerous historical papers and his active commitment to the Sarton-committee, I am delighted that the Sarton medal has been awarded to Prof. Erick Vandamme.

Microbes, Spontaneous Generation, Miasma and Concepts of Origin of Life: from Antiquity till Today.

Erick J. Vandamme,

1. Spontaneous Generation (SG), Miasma, Abiogenesis, Biogenesis, Microbes and Neo-Darwinism

The term "spontaneous generation" (SG) or "generatio spontanea" – alluding to the origin of life – refers to the direct and quick formation of living cells or organisms in the environment from inanimate matter or without descent from similar organisms. For over 3 millennia, spontaneous generation claimed that different types of life -especially small organisms – might repeatedly emerge in a time scale of hours, weeks, or even a few years from sources (other than plant seeds, eggs, or parents) such as river mud, dirt, sand, winds, air, water, sea foam, and flour (1–3).

The Greek natural philosopher Anaximander of Miletus (610-540 BC)[1] (Figure 1) is recognized as the first to have proposed that life developed spontaneously from nonliving matter. Only in the second half of the 19th century was this concept disproved.

1 Figure 1: Anaximander of Miletus (610-540 BC):Greek philosopher; proposed "Spontaneous Generation".

The “miasma”- concept (from the ancient Greek term for “pollution”, a noxious form of “bad air”) – referring to the origin of disease and the cause of loss and the end of life -, was widely accepted and the term was later on heavily advocated by the influential Greek physician, surgeon and philosopher Aelius Galen of Pergamon (also named Galenus) (120 or 129-210 AD)[2] (Figure 2). He stated that (infectious) disease transmission – and eventually end of life – was caused by a miasma or “bad air” or “vapor emanating from rotting organic matter”, not by invisible pathogenic microorganisms (bacteria, fungi, protozoa, viruses,…) as we know better today. This concept also had its believers and defenders from antiquity till the 1880s (3,4).

Despite the term SG had been around for centuries and stood so long without any discussion, the English medical physiologist Henry Charlton Bastian (1837-1915) was one of the first scientists to openly dislike the ambiguity of the name SG and he initially referred to it as “archebiosis”, his term for life originating from inorganic matter. However in 1870 he also coined the term “biogenesis” for formation of life from nonliving matter (5). To further complicate the matter, since 1859 another term -“heterogenesis” – was introduced by the famous French naturalist Félix Archimède Pouchet (1800-1872) to describe the generation of living organisms from totally unrelated organisms or from once living organic matter (6,7).

Soon after the two Bastian’s terms – archebiosis and biogenesis – were coined, the influential English biologist Thomas Henry Huxley[3] (1825-1895) (Figure 3) introduced – in a more logical way – the new term “abiogenesis” for life originating from nonliving matter. However, in order to avoid further confusion, since his term “abiogenesis” was related to Bastian’s term “biogenesis”, he “hijacked” Bastian’s term and adopted “biogenesis” for the process where life arises from existing life (8,9).

[2] Figure 2: Aelius Galen of Pergamon (c.129-210 AD): Greek physician and philosopher; advocate of” Miasma

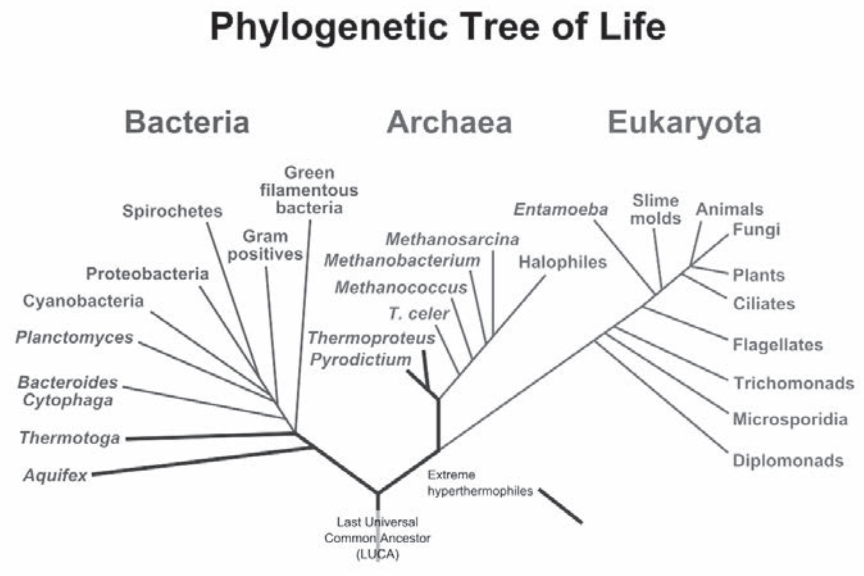
[3] Figure 3: Thomas Henry Huxley (1825-1895): English biologist; redefined the terms “Abiogenesis” and “Biogenesis” .

It is Huxley's term "abiogenesis" that is currently still in use to refer to the early physical and chemical events that led to the abiotic formation of biomolecules and the origin of life. This process finally resulted in the first life on planet Earth, that then evolved over a time span of over 4.0 billion years to the diversification of life as is currently known. Several major ideas or hypotheses about this evolutionary process melted into a combination of Darwin's natural selection, genetic variation and Mendelian inheritance, now often designated as neo-Darwinism (10). These ideas and hypotheses are now backed up by numerous (micro)-fossil records, rock and meteorite isotope-chemistry analysis and broad – though not complete – experimental evidence such as chemical and physical simulation of early Earth conditions, microbial mutation studies, horizontal gene transfer, and – recently – whole genome sequencing and "uncultured bacteria"-genomics (11).

2. Origin of Life: still a matter of debate!

Spontaneous generation as well as the miasma-concept as defined above (to describe respectively the origin and the end of life) are now obsolete propositions, but they were taken for granted for over more than 3 millennia. The origin of living (micro)organisms and life in general has always intrigued mankind as is evidenced from ancient documents as well as from recent research and opinions (3,12–24). Even the introduction of the microscope and the first viewings of microorganisms (fungi, protozoa, bacteria,...) in the 17th century, nor the propositions of the germ theory of disease with different microbial agents causing different diseases in the late 18th century did not directly lead to disbelief in SG and miasma! In hindsight, the impact of the discoveries of Louis Pasteur and Robert Koch – and their collaborators and successors – proving that these tiny microbes were abundantly present on Earth, and were able to display good and bad activities towards people and on all other life forms ....and on the planet itself, was – unknowingly and basically – very instrumental to the start of science based studies on the origin and evolution of life on planet Earth.

However the origin and the complex physical/chemical route towards the first ever (microbial) "protocell" and life on early Earth – the prebiotic phase – remains a matter of debate till today (15,24–31). The evolutionary road from the first "protocell" to the "*Last Universal Common/Cellular Ancestor*" or LUCA, now accepted as the most recent common ancestor, forming the base for the three evolved domains of the family tree of life we know today – *Prokarya, Archaea and Eukarya*[4] – (Figure 4), involves several steps that remain unresolved (29,31-33). Recent research based on "uncultured bacterial-genomics" and artificial ribozymes will further expand our views on microbial diversity and interrelations. It may eventually alter our current understanding of the family tree of life (11, 19-23).



Despite the lingering controversy, a broad consensus existing up till recently that LUCA must have had DNA (deoxyribonucleic acid, having deoxyribose as a sugar moiety) as genetic material, as well as having RNA (ribonucleic acid) and proteins to catalyze essential processes for growth and reproduction, and a lipid membrane to enclose and protect all its components (34-38). However, RNA – having ribose as a sugar moiety – carries also genetic information (as still in RNA viruses today) and it displays catalytic properties (such as in ribozymes) in all types of cells. Due to this versatility, RNA is now also seen as a candidate first-genetic-material, to be considered as the initial first self-replicating genetic material, a theory called the "RNA-world" (39). In 2019 sugar molecules such as ribose (present in RNA) and others –though not deoxyribose (present in DNA) – were detected in meteorites by Japanese and NASA researchers (30). IT

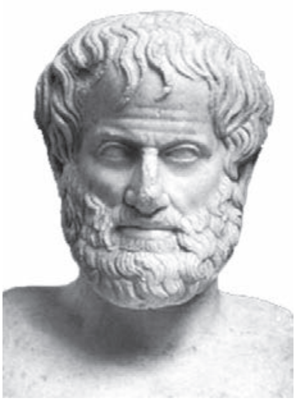
[4] Figure 4. A 1990 "Phylogenic Tree of Life", linking all major groups of living organisms to the Last Universal Common/Cellular Ancestor (LUCA).

gives evidence of extraterrestrial ribose and other bio-essential sugars in primitive meteorites as carriers of prebiotic organic molecules to the early earth and it may have contributed to forming functional biopolymers like RNA. Other authors propose that both DNA and RNA derived later on from a precursor molecule, named threo-nucleic acid (TNA), that is based on the simpler sugar moiety threose rather than deoxyribose (in DNA) or ribose (in RNA) (19-21,23, 40-43). Studies with a range of such "xeno-nucleic acids" (XNAs) will allow to assess whether DNA and RNA are the most efficient and desirable building blocks of life, others pretend the two molecules were chosen randomly after evolving from a larger class of chemical ancestors (19-23).

Anyhow before LUCA was formed, there was a prebiotic phase, where life's essential molecules and building blocks were generated – possibly in several attempts – via a range of random "spontaneous" chemical and physical reactions and interactions, a proposition and process still arousing debate and doubt (3,16,17,22,23,25,29,38,44,45). It is also speculated that small RNAs and bacteriophage/virus-like particles were the first biological try-outs (and remnants) of the evolutionary process of life on early Earth. It is assumed that life came into existence only towards the end of the geological Hadean eon (4.6 to 4.0 billion years ago or bya) (28,50-52) or towards the start of the early Archean eon, named Eoarchean (4.0 to 3.6 bya) (53,54).

3. Antiquity and Advocates of Spontaneous Generation and the Miasma Theory

As to the origin of life, Babylonian clay tablets (1800-600 BC) mentioned that worms were generated from river mud. Chinese recordings from the Shang Dynasty (ca. 1600-1050 BC) and ancient Indian documents described that aphid insects are spontaneously generated from bamboo, and that flies are generated from dirt and soil. Old Chinese local chronicles mention miasma indirectly as a poisonous gas emanating in the environment and as a cause of a range of diseases and of killing off life. As to the Western world, the Greek natural philosopher Anaximander of Miletus (610-540 BC) (see Figure 1) proposed in his book "*Peri Physeos*" (On Nature) that life developed spontaneously from nonliving matter. He believed that all things arose from the elemental nature of the universe (water, earth, fire and air) and that the primal chaos of the universe was eternally in motion and served as a substrate where elemental opposites (wet and dry, hot and cold) generated a terrestrial slime that shaped the many varied plants and animals of the world. His pupil Anaximenes proposed that air was the element that brought life and endowed creatures with motion and thought. The poet and philosopher Xenophanes of Colophon (560-470 BC) described fossil imprints of plants and animals and concluded from his findings that the world had indeed changed when compared to his time, suggesting a cyclic evolving natural world (55). Empedocles of Agrigento (480-430 BC) accepted "generatio spontanea" of life also from the four elements, but proposed that water, earth, fire and air had combined in different ways that interchanged over time in cohesion and chaos to yield in the end different life forms (56,57).



The famous philosopher and all-round polymath Greek scientist Aristotle[5] (384-322 BC) (Figure 5) theorized extensively on the reproduction of man and animals, whereas his colleague and successor Theophrastus (ca. 372-287 BC) specialized in the study of plants and minerals. For example, Aristotle proposed in his books "*Historia Animalium*" and "*De Generatione Animalium*" that bivalves and snails were generated from mud, scallops from sand ("abiogenesis") and that eels emerged from earthworms. Of interest is that he discussed sexual and parthenogenetic generation as well. Aristotle's view had an enormous impact and supported a strong belief in SG that lasted throughout the next two millennia (58). The Roman author, architect and engineer Marcus Vitruvius Pollio (ca. 75-15 BC) advised that libraries be built facing eastwards to benefit from morning sun, not towards the south or the west as those winds generate bookworms. Even as a Christian theologian and philosopher, Saint Augustine of Hippo (354-430 AD) followed this dominant view on SG as postulated by the above mentioned philosophers and thinkers. He discussed SG in his books "*De Civitate Dei*" (The City of God) and "*De Genesi ad Literam*" (The Literal Meaning of Genesis), citing Biblical pas-

[5] Figure 5: Aristotle (384-322 BC): Greek philosopher and scientist; strong proponent of "Spontaneous Generation"

sages such as “Let the waters bring forth abundantly the moving creatures that have life” as laws that would enable ongoing creation (59).

As to the origin of infectious diseases, the Greek general and historian Thucydides (ca. 460-400 BC) who described the plague of Athens (typhoid fever, caused by *Salmonella enterica* var. *typhi*- bacteria) in his “*History of the Peleponnesian War”*, is considered the first to have stated that disease could spread from person to person (“contagionism”), but also by “seeds” present in the “miasma” air. He also noted that people surviving the plague did not catch the disease again (60). The Roman scholar and writer Marcus Terentius Varro (116-27 BC) wrote in his “*Rerum Rusticarum Libri III”* (Three Books on Agriculture) that swamps are to be avoided “since certain minute creatures which cannot be seen by the eyes float in the air and can enter the body and cause disease”. The Roman poet Lucretius (99-55 BC) wrote in his poem “*De Rerum Natura”* (On the Nature of Things) that the world contained various “seeds” possibly sickening a person whether inhaled as air or taken in as food. Galen’s (ca. 129-210 AD) “miasma-concept” of bad air, loaded with “seeds”, was based on these views and was generally accepted in Europe and in China. Galen speculated further that some patients carry “seeds of fever”. He also spread the – wrong – opinion that wound pus was important for the healing of wounds and that plagues and epidemics were caused and spread by seeds of plague that are present in “bad air”. In his book on “*Epidemics”* he explained that “patients may relapse during recovery because the seeds lurked in their bodies” and eventually may end its life (3,4,58).

4. Spontaneous Generation and Miasma during the Middle Ages and Renaissance

With the fall of the Roman Empire in 476 AD up to the East-West Schism in 1054, the influence of the Greek philosophers and their science declined. However, belief in spontaneous generation as well as in the “miasma”-concept (“bad air” theory of disease transmission) stayed on. Galen’s ideas lingered on throughout the Middle Ages. For example, Isodore of Seville, Spain (ca. 500-636 AD), also mentioned the plague bearing seeds in his work “*On The Nature of Things”*. Later in 1345 Tommaso del Garbo (1305-1370) of Bologna, Italy, also mentioned Galen’s seeds of plague in his book “*Commentaria non parum utilia in libros Galen”* (*Helpful commentaries on the book of Galen)* (3,4,58).

Old Chinese local chronicles mention indirectly miasma as a poison gas, emanated in the environment from rotting vegetation, swamps and foul water, and as a cause of a range of diseases. From the Western – Jin Dynasty (266-420 AD) onwards, the Sui – Dynasty (518-618 AD) and the Tang – Dynasty (618-907 AD) recorded officially that different types of miasma-diseases occurred in several locations in China. Especially Southern China was hit by "poisonous air and gases". During the Ming (1368-1644) and Qing (1644-1912) dynasties, the environmental and urban sanitation was gradually improving and in the 19th century Western science and medical knowledge were introduced and miasma-belief faded out.

Aristotle's abiogenesis and SG views were reintroduced into Western Europe in Arabic translation and reached the widest acceptance in the 13th century, when Latin translations became available, also under the influence of theologian, philosopher and jurist Thomas Aquinas (1225-1274). It was discussed in the literature well into the Renaissance (13-16th century), when even William Shakespeare (1564-1616) mentioned that snakes and crocodiles were formed from mud of the Nile. However, change was to come based initially on meticulous studies of the various and differing stages of insect development (egg, larva, pupa and adult) (3,4,53,58).

5. Gradual Disbelief in Spontaneous Generation: Influence of 16th to 18th Century Scientists

From the 16th century onwards, ancient beliefs in SG were put to the test. The Flemish chemist, physiologist and physician Jan Baptist van Helmont (1580-1644) is considered as one of the first to perform experiments to check biological phenomena. According to him, tree growth was due to water uptake and food was not digested by the body's heat but was aided by a "ferment" within the body (59,60,61). In 1632 the famous English physician, anatomist and physiologist William Harvey (1578-1657) described blood circulation in the body. He also concluded, based on dissecting pregnant deer, that life originates from invisible "eggs", since these embryos are not visible during the first month of pregnancy. In his book "*Exercitationes de Generatione Animalium*", he expressed that everything originates from eggs ("Omnia ex Ovo") (59,60). Italian physician, biologist and poet Francesco Redi (1626-1697) challenged in 1668 the then still generally believed idea that maggots arose spontaneously from rotting meat by a series of experiments with meat placed in gauze covered open and closed jars. Flies could only enter the open jars, deposit their eggs and only under those conditions could maggots appear. Then Redi collected them and waited for them to metamorphose into flies. He used his experiments to support the preexistence theory of the Church at that time, stating that living things originate from their parents. He formulated his famous adage "omne vivum ex vivo", all life comes from life. He described in 1684 that parasites of diseased animals produce eggs from which offspring are developed (60,62). The Dutch biologist and microscopist Jan Swammerdam (1637-1680) rejected as a first the concept that one animal could spontaneously arise from another one or from putrefaction just by chance and thus he doubted spontaneous generation. However, he associated it with an atheistic view, a fact he could not support (63).

All these experiments disproved the prevailing opinion that these small "animals and parasites" were spontaneously generated or by miasma. A few decades later Italian botanist Pier Antonio Micheli (1679-1737) described in 1729 detailed characteristics of 1.900 plants and 900 fungi. He observed fungal spores, when placed on melon-slices, to reproduce the same fungus types as those the spores came from. Based on these observations he noted that fungi did not arise from SG. English biologist and priest John Needham (1713-1781) also experimented in 1745 on SG. He believed that boiling broths in flasks would kill all living things, but upon cooling in the open air ("bad air") and subsequent sealing, the broths would cloud again (in hindsight by growth of microbes). These findings allowed the belief in SG and in miasma to persist, despite the microscope becoming available since the 1680s to these early researchers (59,60,64). Needham, and also the influential French naturalist George-Louis Leclerc, Comte de Buffon, (1707-1788) concluded that there is a life generating force inherent to certain types of inorganic matter that causes small living cells and organisms to create themselves (60).

Over time these small organisms were indicated as "minute" creatures, seeds (of fever/plague), small worms, small animals, germs, ... The Dutch draper and lens-maker Anthony van Leeuwenhoek (1632-1723) had named in the 1670s what he observed with his microscope as moving small organisms, as "animalcules". Much later the German naturalist Christian Gottfried Ehrenberg (1795-1876) introduced in 1838 the term "bacteria". The general term "microbe" was introduced by the French military surgeon Charles-Emmanuel Sédillot (1804-1883) in 1878.

It was an Italian priest, biologist and physiologist Lazzaro Spallanzani[6] (1729-1799) (Figure 6) who really challenged in 1768 the theory of SG of "microbes" in modifying Needham's experiment by boiling broths for over one hour in sealed containers (with the air partially evacuated to prevent explosions), with no reappearance of microbes as a result. He proposed that "microbes" moved in through the air and that they could be killed through boiling (9,58,60,65). Over time many similar observations demonstrated that, when careful experimentation was followed, biological reproduction was based on existing complex cell-structures rather than on muds and dead material.

More proof came in 1837, when independently the German physiologist Theodore Schwann[7] (1810-1882) (Figure 7) and the French inventor and physicist Charles Cagniard de la Tour (1777-1859) discovered yeast and yeast cell division in alcoholic fermentations and by microscopic examination of foam from the beer brewing process. Beer fermentation would not occur if dividing yeast cells were not present. Also, when sterile air was introduced in the beer broth and no yeast cells were present, fermentation would not start. In retrospect, Anthony van Leeuwenhoek had observed in 1680 such "small spherical globules" under his microscope, but did not consider them as living cells. Schwann's observations further damaged the claims at that time that SG was involved in all fermentation processes. He had observed that aeration of vessels, filled with broth, with heated air (as oxygen was

6 Figure 6: Lazzaro Spallanzani (1729-1799): Italian biologist; first attempts to disprove of "Spontaneous Generation".

7 Figure 7: Theodore Schwann (1810-1882): German physiologist; yeast cells are essential to brew beer.

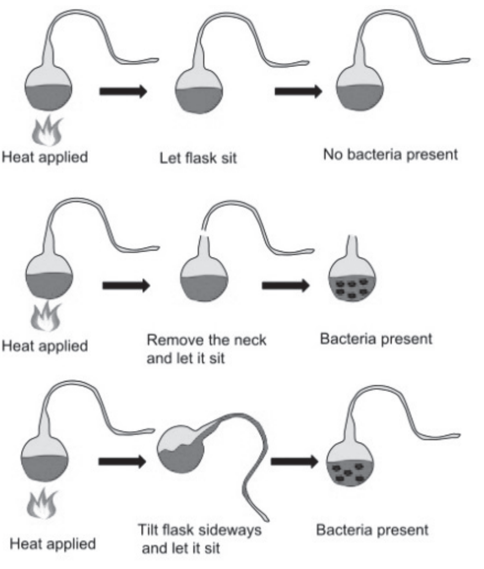
believed to be essential for SG to occur) prevented microbial growth. He thus concluded that the microbes present in the air had been destroyed by the heat and that microbes in "bad air" were the cause of miasma and that good microbes like yeast caused the desirable beer fermentation (66).

6. Impact of Louis Pasteur (1822-1895), Robert Koch (1843-1910), John Tyndall (1820-1883), Charles Chamberland (1851-1908), Martinus Beijerinck (1851-1931) and Sergei Winogradsky (1856-1953)

Decisive experiments by French Louis Pasteur[8] (Figure 8), German Robert Koch and Irish John Tyndall were to settle forever the over 25 centuries lingering dispute about spontaneous generation. The debate on SG culminated in the late 1850s in France, when the French naturalist Félix Archimède Pouchet (1800-1872), a leading proponent of SG, challenged the views of Theodore Schwann and of Louis Pasteur. Both supported the germ theory, stating that microorganisms/germs arose from germs and those from parents of the same species and also that germs were present everywhere, including in the air, soil, water and on inanimate matter (fomites). Although Pouchet was a renowned animal physiologist, he assumed that living things originated from inanimate matter, including air, calling the process "heterogenesis". In 1858 Pouchet contested Schwann's results based on his own similar experiments. Chemist ànd microbiologist Louis Pasteur wrote to Pouchet in 1859, mentioning that he respected his belief in SG, but that he did not agree with his experimental results because of a poor experimental set up. Despite this criticism Pouchet published in 1859 his major scientific book (in French) "Heterogenesis or Treatise on Spontaneous Generation", endorsing SG in claiming that the eggs of adult organisms are spontaneously generated, not the adults themselves (6,7).

[8] Figure 8: Louis Pasteur (1822-1895): French chemist and microbiologist; disproves "Spontaneous Generation".

To solve this controversy, the French Academy of Sciences, in favor of Pasteur's views, established in January 1860 a prize for detailed experimentation that could solve this matter once and forever. Pasteur decided to participate in this competition with the well-known outcome of the result. His sterile broth containing flasks open to the air with a downwards curved swan neck tube[9] (Figure 9) remained sterile for days, until the "air-dust" (particles/spores/ bacteria) collected in the neck was allowed to enter the flasks by purposefully tilting the flask to allow the broth to reach the "bad air dust". Louis Pasteur's "famous but simple" experiments of 1860-1861 are now widely accepted as being decisive for finishing off SG and miasma (6,7,9,60,67). Also, the prominent Irish physicist John Tyndall, a correspondent and admirer of Pasteur, further contributed to the complete fall of SG in the period 1876-1881 by developing a method for fractional sterilization, named "Tyndallization" of broths that killed also bacterial endospores, that normally survived boiling as demonstrated in 1876 by German botanist Ferdinand Cohn (1828-1898). The unknown -but universal- presence of these bacterial endospores in broths and samples led initially to the failure of many experiments aimed at disproving SG and – in hindsight – Pasteur must have been lucky such endospores did not spoil his experiments. Tyndall described his experiments in a book "*Assays on the Floating Matter of the Air in Relation to Putrefaction and Infection*" (68,69).



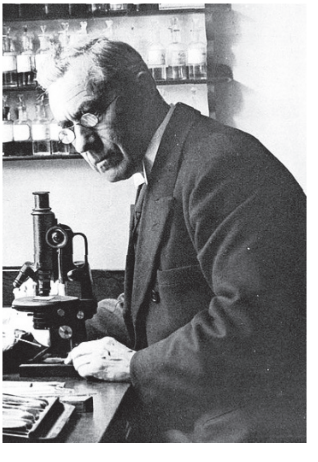
Also German physician and famous medical microbiologist Robert Koch (1843-1910) contributed a lot with his introduction of the use of solid agar-culture media in Petri-dishes, and with his postulates, providing in 1876 a logical proof of Pasteur's germ theory of disease, and killing the mias-

9 Figure 9: Diagram of Pasteur's swan neck tube-flask experiment.

ma-concept altogether. Even he was heavily opposed by a Bavarian chemist and public health-hygienist, Max Joseph von Pettenkofer (1818-1901), the Director of The Institute of Hygiene, Munich, Germany. Although being an influential and rightly proponent of safe water provisions in cities, fresh air and proper sewage disposal and sanitation systems, he did not believe in the novel concept that bacteria and other microbes were a main cause of diseases, putrefaction and fermentation and he remained convinced that a factor in "bad air" combined with a factor in the soil caused cholera, and not *Vibrio cholerae* bacteria as proven by Koch in 1884. As a last influential "miasmatist" von Pettenkofer came into personal conflict and on a collision course with famous Koch, who won this battle of opinions convincingly in the following years. The scientific tide had turned against him and this led disgraced von Pettenkofer to take his own life in 1901 (70,71).

About two decades earlier, Pasteur's coworker Charles Chamberland (1851-1908), developed in 1879 the autoclave, allowing to sterilize materials and liquids under overpressure at 121°C. The material is now universally in use and essential in fundamental and applied research and in industry, related to the microbiology, biotech, fermentation, pharma, medical, food and sanitation sectors. Also in 1884, he developed unglazed porcelain filters, with pores smaller than the size of bacteria (< 0.3 micrometer) -though not the size of viruses (then unknown)-, enabling the sterilization of liquids without heating and the preparation and isolation of then called "filterable viruses" (72,73). This filter system allowed not only to prepare healthy drinking water at home but also to detect and monitor the infectious disease effects of such "bacteria-free"-filtrates.

As a first tobacco mosaic virus (TMV) – causing tobacco plant disease -, was noticed to be an infectious plant disease in 1886 by German agro-chemist Adolf Mayer and subsequent studies in 1892 by Russian botanist Dmitry Ivanovsky indicated that a non-bacterial pathogen was involved, based on use of the Chamberland-filter. Finally in 1898 Dutch botanist and microbiologist Martinus Beijerinck[10] (1851-1931) (Figure 10) confirmed at Delft



[10] Figure 10: Martinus Beijerinck (1851-1931: Dutch botanist, microbiologist; proves the existence of viruses

University the viral nature of the TMV-disease. In the following years and decades, several other plant, animal and human infectious diseases were found to be caused by viruses rather than bacteria, fungi or protozoa. In the period 1915-1917, it was found that even bacteria could become infected by viruses; these bacterial viruses were named "bacteriophages" (72,73).

Beijerinck also obtained in 1888 as a first pure cultures of the plant root nodule bacteria *Rhizobium* sp. and studied the important process of biological nitrogen fixation. Using enrichment culture techniques, he isolated from water- and soil- samples luminescent bacteria (*Photobacterium sp.*) in 1890, sulfate-reducing bacteria (*Desulfovibrio sp.*) in 1895 and sulfur-oxidizing bacteria (*Thiobacillus sp.*) in 1904. His Russian contemporary Sergei Winogradsky[11] (1856-1953) (Figure 11) studied microbes involved in the biogeochemical cycles at the universities of Strasbourg, France, and Zurich, Switzerland, and -after retirement- in 1922 at the Institut Pasteur, Paris, France. He described photosynthetic bacteria such as *Beggiatoa* sp. (in 1887), purple sulfur bacteria (in 1922) and nitrifying bacteria (*Nitrosomonas sp.*) in 1890. He advanced the principle of autotrophic metabolism (in 1890) and isolated the first free-living anaerobic nitrogen-fixing bacterium *Clostridium pasteurianum* (in 1895). Both famous microbiologists established the fields of agricultural microbiology, soil and water microbiology, microbial ecology and (micro)nutrient biogeochemical recycling, revealing the huge essential ànd beneficial roles and impact of environmental microbes on planet Earth. Also agronomists, geologists, mineralogists, archaeologists, ... became interested in this field of geomicrobiology (50,74).

[11] Figure 11: Sergei Winogradski (1856-1953): Russian microbiologist; stud y of microbial biogeochemical cycles in nature

7. Impact of 20th Century Scientific Contributions: Viruses, Electron Microscopy, (Micro)-Fossil Records, Rock and Meteorite Isotope-Geochemistry, Molecular Biology, Whole Genome Sequencing, "Uncultured Bacteria"-Genomics, ...

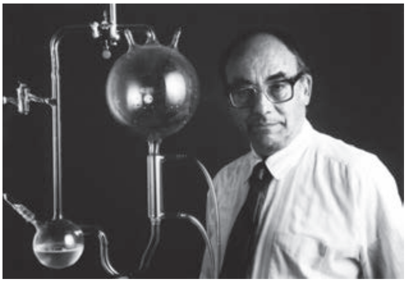
It took till after mid-19th century to finally disproof experimentally that SG did ever occur, that the miasma-concept had no grounds at all and that both these phenomena were caused by invisible living small things "microbes" (bacteria, yeasts, fungi, protozoa, micro-algae, viruses, ...), only to be seen with the aid of the microscope. It became then also clear that only some microbes cause diseases, while the majority carries out beneficial activities for mankind and for nature. As outlined above the existence of these microbes was till then totally unknown and their origin on Earth is even today a matter of debate. At that time, the term "virus" (derived from Latin, referring to "poison") was broadly in use to name any disease-causing microbe. As indicated above the existence of the "true" viruses (in the modern meaning) was unknown till 1898. Viruses and bacteriophages were first visualized only in the early 1930s with the invention of the electron microscope. USA biochemist Wendel Stanley (1904-1971) and his team demonstrated in 1936 that TMV capsid-protein could be crystallized and in 1939 that TMV had -surprisingly- RNA as "nuclein" material, while DNA had been shown by German biochemist Albrecht Kossel (1853-1927) in 1881 to be the universal "nuclein"! Today viruses and phages are classified based on having either DNA or RNA as genetic material and on their typical genome sequences next to other physical, morphological and chemical characteristics as well as host range. Viruses can only "replicate" inside other living cells of humans, animals, plants and microorganisms, including bacteria, and they lack some key characteristics of life. *T*he origin of viruses is still a matter of debate nowadays (75-80).

At the turn of the 19th century, the ensuing awareness of the omnipresence and abundance of microbes and viruses and the fact that they can perform beneficial processes such as a wide spectrum of useful fermentations, that they are crucial in the recycling of organic and inorganic matter (carbon, nitrogen, phosphorous, sulphur, ...- cycles) in nature as well as being – in some cases – the cause of a range of infectious diseases, did gradually lead to interest as to their origin and primordial role in the evolution of all lifeforms on Earth. In the first half of the 20th century, basic and applied (bio)chemistry, analytical and geochemistry, electron microscopy, microbial genetics, mutation studies and industrial fermentations made great strides, while in the second half the universal genetic code was elucidated, recombinant DNA-technology was born and applications of targeted (like 16S rRNA) -gene sequencing and whole genome sequencing (useful in microbial and general taxonomy), polymerase chain reaction (PCR) technology and use of metagenomics and bio-informatics became routine technologies. Recently the genomics of "unculturable bacteria" reveals the importance of microbiomes – complex bacterial communities – in nature and inside and on the surface of all life forms (11). All these discoveries and technologies – mostly initially based on research with bacteria – broadened even more the vision about the huge potential and impact of this invisible "microbial world" on life, society and planet Earth (3,38,50,74).These basic sciences and bio-technologies became also extremely helpful in the ongoing search for the origin of life on Earth.

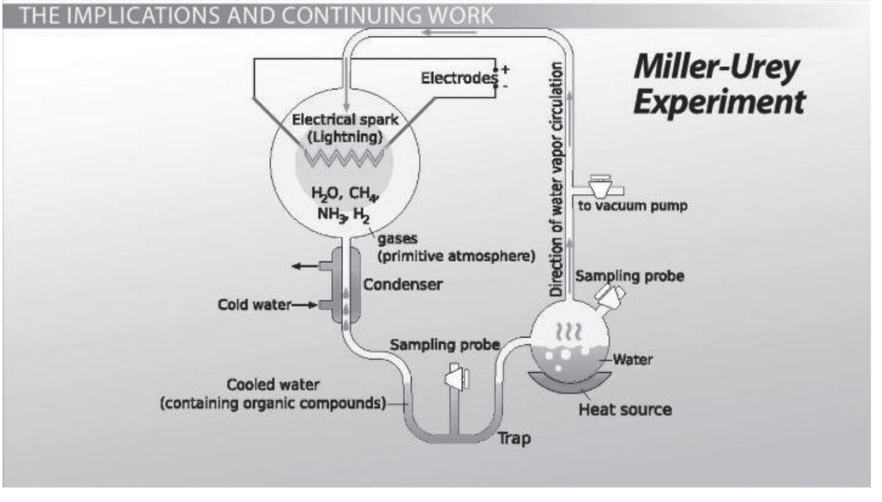
8. Origin of First Life from Non-Living Matter ("Abiogenesis" or Prebiotic Evolution) and Subsequent Evolution of Life

8.1. Earth's Primordial Soup

From the 1920s onwards, hypotheses on the prebiotic evolution were formulated in 1924 by the Soviet biochemist Alexander I. Oparin (1894-1980) as well as in 1929 by the British visionary biologist and statistician John B.S. Haldane (1892-1964). The formation of organic biomolecules, such as amino acids, hydroxy acids, aldehydes, and other biomolecules, could have been formed by the effects of atmospheric forces (UV-radiation, lightning, space dust, etc.) or by volcanic activity on the gases of the prebiotic Earth's atmosphere (methane, ammonia, water, hydrogen sulfide, carbon monoxide, etc.) and/or on abiotic inorganic solutes (in superheated thermal vents) in the Earth's deep oceans. This theory of the Earth's "primordial soup" being the origin of first life became known as the Oparin-Haldane hypothesis (81-85).



This hypothesis was put to the test in 1953 in a now classical experiment carried out by chemist Stanley L. Miller[12] (1930-2007) (Figure 12) in the laboratory of the Nobel Prize winner Harold C. Urey at the University of Chicago, IL, USA. His experiment,[13] as shown in Figure 13, did confirm that the above-mentioned biomolecules could arise by chemical evolution on the prebiotic Earth (86,87). Since then, more sophisticated lab experiments and sensitive analyses have provided ample evidence that many chemical components of living cells (amino acids, amines, peptides, ribonucleotides, RNA-like molecules, and others) can form under such harsh conditions (26,27,88-90). Furthermore, it has been demonstrated that short RNA molecules can indeed act as catalysts (based on both natural and artificial ribozymes) in their own formation as well as in that of other biologically significant reactions such as condensation of amino acids into peptides (as in "modern" ribosomes) (39,39a,39b). Lipid-like compounds in the primordial soup could spontaneously form bilayer structures able to enclose primitive proteins and nucleic acids to form primitive cellular



[12] Figure 12: Stanley Miller (1930-2007): American chemist. Copyright © 1981 The Regents of the University of California. All Right Reserved. Used by permission

[13] Figure 13: Diagram of S. Miller's experiment. From Wikimedia Commons. Permission is granted to copy/distribute the document under the terms of the GNU Free Documentation License

entities or "protocells". The first cells were not as complex as the current microbes and their type of metabolism is unknown. Based on these propositions and facts, it is now generally agreed that the first proto-microorganisms were probably anaerobic chemoautotrophs (13-17,91-93). Anaerobic chemoautotrophic bacteria and archaea (such as acetogens, methanogens, and others) are today still abound on Earth in locations such as in deep sea vents, marshes and in volcanic areas. However, these results suggest a long evolution after LUCA.

8.2. Current Views on Origin of Early Cells (Microbes) and Subsequent Microbial and Organismal Evolution

The Earth was formed about 4.6 billion years ago (bya), then water vapor liquified and oceans formed 4.3 bya ago (mid Hadean eon), and between this event and 3.85 bya (mid Eoarchean eon), biological evolution started with no free oxygen present, with high volcanic land and deep-sea vent activity, but with sunlight and liquid water oceans available. Current views state that life came into existence only near the end of the geological Hadean eon (4.6 to 4.0 bya) or in the early Archean eon, named Eoarchean (4.0 to 3.6 bya) (28-29,51-54).

The first cells probably arose in a reducing atmosphere in hot surroundings and obtained energy from inorganic fuel molecules such as ferrous sulfide (FeS) and ferrous carbonate. Biogenic carbon has been detected in zirconium-silicate-minerals dated 4.1 bya, but this needs to be confirmed (28). Earth was till then very hostile to life. It could have been arisen repeatedly but not sustained. This is the "hydrothermal hypothesis" but another mesophilic "lukewarm little pond" hypothesis seems also possible, where the abundance of clay minerals on early Earth could also be important. The organic biomolecules that were needed may have arisen by non-biological reactions and/or meteorite impacts as described above (27,30,83,84,89,92,93). A scenario, though still controversial, could be that about 3.5 bya, early cells/bacteria gradually became able to derive energy from compounds in their environment and use that energy to synthesize their own precursor organic molecules.

In 1996 the earliest indication of life, ca. 3.7-3.45 bya (mid Eoarchean), was proposed, based on forms of graphite carbon with a distinct biological origin embedded in sedimentary rock, in the Isua supracrustal belt in the

Nuuk area in Western Greenland (94,95). A higher level of the lighter isotope ^{12}C-carbon being present in the rock (leaving an isotopic fingerprint) was interpreted as a biological carbon uptake activity. However, this kind of isotopic traces can be produced by abiotic processes and are not unambiguous traces of life. The earliest putative claimed lifeforms are fossilized tubular shaped microorganisms, found in 2017 in 4.28 billion years old (mid Hadean) iron and silica rich rocks that were once hydrothermal vents in the Nuvvuagittuq greenstone belt in Quebec, Canada (96). However here again, the biogenicity of these fossilized tubes is controversial and even the age of the successions is still under discussion. A further significant evolutionary step was the development of pigments capable of capturing energy from sunlight, to be used to reduce CO_2 to more complex organic compounds. This photosynthetic process initially used H_2S as electron donor yielding elemental sulfur or sulfate as byproducts. In rocks that are 3.5 billion years old or younger, fossilized microbial formations called stromatolites are quite common, such as in sedimentary sandstone formations in Pilbara (54) and in baryte (barium-sulfate) deposits in the Warrawoona Group formation (53,97), both in Western-Australia. Isotopic evidence for microbial sulphate reduction was recorded in the baryte mineral. These microbial formations consist of mats of layers of probably filamentous anoxygenic photobacteria, although no unambiguous microfossils have been found (45,98-100). Microfossils have been found that are about 3.45 and 3.2 billion years old but their identity and metabolism are still unknown. Around 2.45 billion years ago, and perhaps earlier, some cells developed the capacity to use H_2O as electron donor, liberating O_2 as "waste". Cyanobacteria are the descendants of these early oxygenic photosynthetic bacteria that gradually brought oxygen in the Earth's atmosphere. With the development of an atmosphere enriched in oxygen by cyanobacteria, aerobic bacteria appeared that were able to obtain energy by passing electrons from fuel molecules to oxygen (100-102). Starting 1.7-1.5 billion years ago, fossil records show evidence of larger and more complex organisms, the earliest eukaryotic cells, still being unicellular. DNA-protein complexes ("chromosomes") were formed and intracellular compartmentalization stabilized the cell content (100-102). In 2018, at the Australian National University, Canberra, scientists reported the presence of intact porphyrin photopigments that are typical for cyanobacteria in marine black shale sedimentary rock of the Taoudeni Basin in Mauritanian Sahara, Africa; these rocks dated as being 1.1 billion years old, which is 600 million years older than reported in previous findings (103). At that time period, the oceans of the Earth were redox stratified and virtually devoid of multicellular animal life, but early eukaryotes, such as multicellular red microalgae, were already diversifying and their microfossils were preserved in the same sediments (104). The nitrogen isotopic values of the fossil pigments showed that the oceans were dominated by cyanobacteria, while larger planktonic algae were scarce. Based on fossil carotenoid pigments, anoxygenic green (*Chlorobiaceae*) and purple sulfur bacteria (*Chromatiaceae*) also contributed to photosynthesis. Furthermore in 2017-2018, it was found – based on the absence of diagnostic eukaryotic steranes in the time interval of 1.6-1.0 billion years ago – that algae did not yet play a significant role in these mid-Proterozoic oceans (103,104).

These fossil records indicate that bacterial life dominated planet Earth for about the first 3 billion years, until larger planktonic algae and then metazoans appeared. These recent findings support the hypothesis that masses of small bacterial cells then at the base of the food chain limited the flow of energy to higher trophic levels, potentially retarding the emergence of more complex multicellular life forms, such as animals, that appeared only 800 to 600 million years ago. Despite these recent findings, it remains difficult to establish the link between primary bacterial production and the late proliferation of larger and complex organisms because the mid-Proterozoic rock record (1.8 billion to 800 million years ago) is nearly devoid of recognizable phytoplankton fossils.

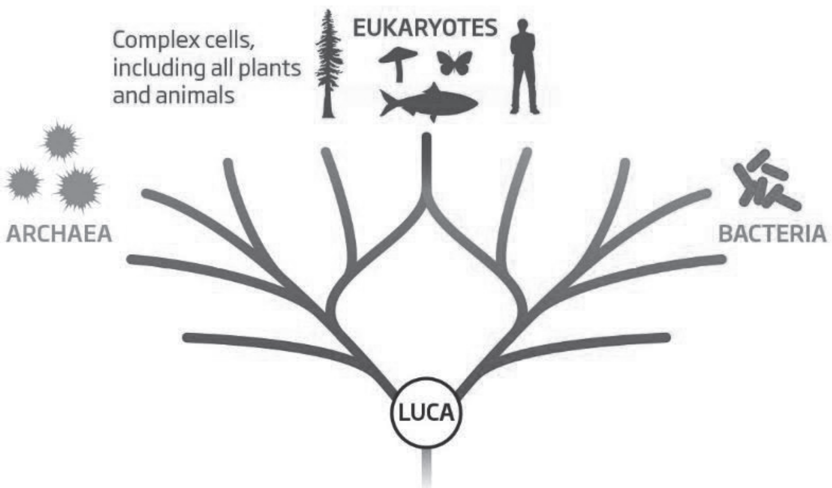
More than 1.1 billion years ago, early eukaryotic cells had enveloped aerobic or facultative anaerobic protobacteria and photosynthetic cyanobacteria to form endosymbiosis-associations that became permanent and led to mitochondria of modern eukaryotes, and to the plastids and the chloroplasts of algae and plants, respectively. This is now confirmed based -among others- on the 70S ribosome size (S= Svedberg units) of these eukaryotic cell organelles, a value similar to the ribosome size of current bacteria, versus the 80S ribosome size in the eukaryotic cytoplasm (105,106). At much later stages, less than 1.0 billion years ago, unicellular organisms clustered together to gain efficiency. This led eventually quite late, at about 800 to 600 million years ago, to the first highly differentiated metazoan organisms as we know them today. In parallel today, bacteria and archaea continue to inhabit every ecological niche in the biosphere and evolve and adapt even to manmade conditions quickly.

The origin of viruses is still matter of debate: a) they may have derived from escaped pieces of RNA or DNA, that can move between cells as a means of horizontal gene transfer; b) they may have evolved from small cells that parasitized larger cells /bacteria; c) viruses may have evolved from complex molecules of protein and nucleic acid at the same time that cells first appeared (47,78,79,107-109). Viruses did not leave behind physical fossils since they are far smaller than the finest colloidal fragments forming sedimentary rocks, that fossilize larger organisms, such that indirect evidence need to be used to reconstruct their past (47,48,109). Viruses may cause evolution of their host cells upon infection, and the DNA signature of that evolution can be interpreted today: viral genetic fragments that were integrated into the germline cells of an ancient organism have been passed down to our time as "viral fossils" or endogenous viral elements (EVE's). Such DNA sequences are a valuable source of retrospective evidence about the evolutionary history of viruses and have led recently to the science of paleovirology (46).

8.3. Tree of Life or Ring/Web of Life?

The enormous abundance of microbes on Earth is a result of their long evolutionary path. Proof of shared ancestry is the fact that all existing organisms, including humans, contain footprints of a unique ancestor in their DNA. The most useful DNA sequences to reconstruct the evolution of life on Earth are those that encode processes shared by all life forms, such as ribosome mediated protein synthesis. Based on this principle, DNA sequencing technology and comparing 16S rRNA genes and their mutations, USA pioneers Carl R. Woese (1928-2012) and George E. Fox (born in 1945) proposed in 1977 the now iconic three-domain "family *tree of life*", reconstructing the evolutionary history (phylogeny) of various micro- and macro-organisms, leading to three distinct evolutionary groups (domains): *Bacteria, Archaea* and *Eukarya* (110-113). In the meantime, many other genes have been used to reconstruct the genealogy of all life forms based on the accumulation of mutations in the target genes and all data support the tree domain view, with an early branching of *Bacteria* and *Archaea* lineages and the branching of *Eukarya* from the *Archaea* lineage (33,113) (see Figure 4).

Recently with whole genome sequencing technology becoming widely available, entire genomes can be sequenced and analyzed rapidly and inexpensively. This technology allows the consideration of not only mutational changes of rRNA-genes, but also horizontal gene transfer (lateral exchange of genetic material among organisms) as a major driver for genetic variation. Such genome-scale phylogenetic studies support now a "*ring of life" or "web of life*" model, whereby *Eukarya* are no longer a primary lineage but form a chimeric group of a symbiotic origin from the *Bacteria* and *Archaea* lineages, even with the "noncellular" viruses or their genes involved, or with viruses as a distinct but parallel world to cells (18,38,46-48,114). This "ring/web of life" reconciles the genomic data by positioning the *Bacteria* and the *Archaea* as the two primary and ancient lineages evolved from a common "LUCA" ancestor. The *Eukarya* are then seen as a hybrid group that evolved from the *Bacteria and the Archaea*[14]after their diversification had already started (Figure 14).



9. Conclusions and Perspectives

From the above summary of the history of "from belief towards disproof" of spontaneous generation, from old and recent fossil records, advanced laboratory experiments, science based hypotheses and from recent whole genome scale analyses, it is clear that the proposed events leading to the

[14] Figure 14: Representation of the "Ring or Web of Life"

origin of first life on Earth are quite logical: from a prebiotic phase towards a protocell to LUCA. However, the proposed events are not yet resolved in detail, nor is the subsequent evolution of prokaryotic life towards multicellular eukaryotic organisms understood. In addition, several scientific ideas are still circulating with ever more and more facts accumulating to build on these proposed events. It is now widely accepted that all life today evolved from a common ancestor, a primitive lifeform (LUCA) based on a natural process about 4.3 to 3.5 billion years ago. It is not yet resolved whether "genetics" based on the RNA-world hypothesis, being the most popular hypothesis today, came first (39). Or instead was it the DNA world or the protein world hypothesis with focus on proteins and primitive metabolism? Also, not resolved is how membraned cells developed (115-119). Especially the gaps in fossil records, lacunae in proof by chemical and physical experimentation, and biased hypotheses led certain religious and intellectual groups to advocate "creationism" or "intelligent design (ID)", believing that first life and later evolution came about through an intervening designer, creator or god (44). Spontaneous and random early physical and chemical reactions on early Earth must have been instrumental over one billion years for the first form of life to appear, but "spontaneous generation" as outlined above was not involved as can be derived from the ever-increasing scientific evidence for how the first form(s) of life evolved on Earth (11,18,93,119-124).

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Laudatio of Morgan De Dapper

Jan Nyssen

"Borders? I have never seen one. But I have heard they exist in the minds of some people."

It is by these words of Thor Heyerdahl that Morgan used to close his emails, and it is by these words he surely lives his life. Born in 1947, Professor Morgan De Dapper was to become a true *homo universalis,* always searching for new horizons. Morgan's first scientific expedition was to the Cyclades, in Greece, where under the supervision of Prof. Snacken, he prepared his degree thesis on the biophysical environment of the Island Paros. The world is small, 20 years before Morgan, my own mother, also a geographer, was coached in her thesis work by the same Frans Snacken, at that time a graduate assistant.

Morgan's experience in Paros, more than 50 years ago, learned him to work in difficult field conditions, truly preparing him for what was to come next. After completing his degree in Geography at Ghent University in 1969, Morgan decided to start a PhD study in the then Shaba, also known as DRC province. Under the supervision of Prof. Tavernier, and with the support of Prof. De Moor, he completed a geomorphological study on the complex of plateaus near Kolwezi by 1977, based on four years of fieldwork. His work framed in the technical university cooperation between Ghent University and the University of Lubumbashi.

After his mandate as a Geography Department assistant, Morgan gained more leading positions and became lecturer in 1980. In 1991, he became Professor and finally promoted to senior professor in 2009, in subject of physical geography and geomorphology.

Morgan always kept in mind the interaction between humans and the environment – a topic proved to become increasingly important in a world of global change. He approached this interaction in both directions, looking forward, but also backward, and by this gave shape to the discipline of geo-archeology at Ghent University.

The discipline found its roots in the work of Karl Butzer, a geomorphologist from the University of Chicago who was a key figure in UNESCO's archaeological rescue project in Egyptian Nubia in the 1970s. The area would be later flooded by the construction of the Aswan Dam and the creation of Lake Nasser. Due to a lack of time, important operational choices had to be made in which a geomorphic approach proved particularly useful.

In 1980, Butzer defined the 'Contextual Archaeology' as "*the study of archaeological sites as part of a human ecosystem, within which past communities interacted spatially, economically and socially with the environment subsystem into which they were adaptively networked*".

The link with geography is immediately clear, as geography is the study of the integrated system of humans, their activities and their environment. Contextual archaeology is, as it were, understanding these interactions in the past. The geoarchaeological endeavour was accompanied by the support to many Master and PhD students, who under Morgan's guidance got the opportunity to explore the world, and from the high North to the far South achieved expertise in their field.

As a researcher, Morgan De Dapper grew passionate of geomorphology and geo-archeology of the Tropical and Mediterranean environments, especially focusing on the Developing Countries. His research skills gained him already prestige in an early stage, for example as a Laureate of the Royal Academy of Sciences in 1978, and of the Belgian Royal Academy of Overseas Sciences in 1986. Morgan worked in numerous countries, including Portugal, Spain, Italy, Turkey, Syria, Palestine, Jordan, Bahrain, Iran, Egypt, Sudan, the Socotra Island of Yemen, Morocco, Tunisia, Cameroon, Congo, Zimbabwe, Madagascar, Malaysia, Vietnam, Brazil and Rapa Nui a.k.a. the Easter Island. His most recent achievements are the discovery and dating of Pleistocene Rock Art in Egypt and the revealing of important myths and facts from the Easter Island.

His research did not only make it to scientific commons, but it also benefited from the interest of a broader audience, finding its way into newspapers and public lectures.

Achieving excellence in research and teaching was not the limit for Morgan. Besides a charged program here and abroad, he managed to support and promote many national and international organizations, bringing the "geo" sense to it.

Let me take the risk of being incomplete! Morgan has been:

- President of the Belgian Association of Geomorphologists;
- Vice-Chairman of the Belgian Society for Geographical Studies;
- President of the Belgian Royal Academy of Overseas Sciences
- Member of the National Committee for Geography and of the National Committee for the Study of the Quaternary;
- Driving member of the Ghent Africa Platform

and

- Several top functions in the International Association of Geomorphologists, in which he created the working group on geo-archeology.

After retiring, and in his ever-lasting drill, Professor De Dapper however continued his teaching and research activities at our University. Something we sincerely appreciate!

Geoarchaeology: A succesful partnership between Archaeology and Geosciences

Morgan De Dapper

Geoarchaeology is a quite young scientific discipline originating in the 1970s, merely half a century ago, in the frame of a new archaeological paradigm. By that time regional approaches gained momentum in archaeological studies and archaeologists became more aware of the complex range of interactions between human factors and the natural environment in past times. The new paradigm finally resulted in a new discipline: the 'landscape archaeology' or 'contextual archaeology'. Hereby it is assumed the 'natural landscape' has been reorganized either consciously or subconsciously for a variety of religious, economic, social, political, environmental or symbolic purposes.

'Geomorphology', on the other hand, is the interdisciplinary and systematic study of landforms and their landscapes as well as the earth surface processes creating and changing it. A shift in focus took place fifty years ago: geomorphologists came aware of the role of Man as an important factor in landscape formation, mainly by deforestation ensuing accelerated soil erosion on slopes and alluviation in valleys. It became obvious that both disciplines had a strong common interest best served by a close partnership.

That partnership gained major recognition during UNESCO's 'International Campaign to Save the Monuments of Nubia' which took place in the south of Egypt and the north of Sudan between 1960 and 1980. Due to the construction of the Aswan High Dam a large part of the Nubian archaeological heritage was to be swallowed by the rising water of Lake Nasser. Most people remember the relocation – in its entirety – of the Abu Simbel temple in 1968, a titanic technical enterprise (Figure 1).

However, equally important was the fact that many less imposing archaeological sites could be discovered and studied by the archaeologists before their final disappearance. Time was restraint and therefore a geomorphological survey proved to be an invaluable guiding instrument (Butzer & Hansen, 1968). One of the leading geomorphologists was Karl W. Butzer (1934 – 2016) from the University of Chicago (Figure 2).

Figure 1: Dismantling of the temple of Ramses II at Abu Simbel in 1968, during UNESCO's 'International Campaign to Save the Monuments of Nubia' (Source: Wikimedia Commons).

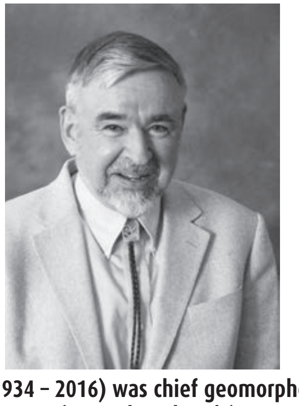

Figure 2: Karl W. Butzer (1934 – 2016) was chief geomorphologist during the Nubia Campaign. He coined the term 'geoarchaeology' (Source: Wikimedia Commons).

He coined the term 'Geoarchaeology' in 1980 (Butzer, 1980). In defining the term 'Contextual Archaeology' as 'The study of archaeological sites as part of a human ecosystem, within which past communities interacting spatially, economically, and socially with the environment subsystem into which they were adaptively networked'. He distinguishes three subdivisions: 'Geoarchaeology' (study and interpretation of physical landscapes = geomorphology), 'Archaeometry' (physical and chemical methods for raw material provenance, dating, site prospection), 'Bio-archaeology' (plant and animal remains, subsistence activities, biotic environment).

After 1980, the 'canonisation' of the term 'Geoarchaeology' was boosted by the publication of 'Geoarchaeology: An International Journal'. This journal emerged from the rapid growth in interdisciplinary research taking place in the 1970s and1980s. Jack Donahue, then based in the Department of Anthropology at the University of Pittsburgh, was the founding editor and the first issue was published in January 1986 (Figure 3).

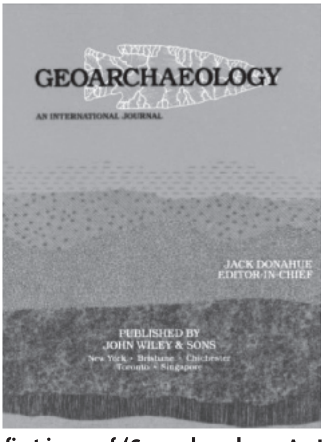

Figure 3: Cover of the first issue of 'Geoarchaeology: An International Journal', published in January 1986 (Source: by courtesy of Jamie Woodward).

The new journal had "the aim to publish research at the methodological and theoretical interface between archaeology and the geosciences including within its scope: interdisciplinary work focusing on understanding archaeological sites, their environmental context, and particularly site formation processes and how the analysis of sedimentary records can enhance our understanding of human activity in Quaternary environments.", (Woodward & Huckleberry, 2009). Although 'Geoarchaeology' is the name of the journal it took into account all geosciences and thus had a wider aim than the original definition of Butzer, including only geomorphology.

Since 1986, there has been an increasing number of articles based on research in Europe, Asia, Africa, Australia, and Oceania. Important progress is obvious in many areas of geoarchaeological and related research, including work on quaternary landscape dynamics, multi-proxy paleoclimatic reconstruction, dating methods, the use of micromorphology in the elucidation of site-formation processes, the geophysical investigation of sites and sediments, the physical and chemical characterization of artifacts and their sources. We even see an improved quantification of the anthropogenic component in site sediment records, and new opportunities are opening up in the application of geoarchaeological methods to forensic science. A wider recognition of the significance of rapid climate and ecosystem change during key periods in the development of Man has produced a new research agenda for the study of the Late Pleistocene and Holocene in all parts of the globe as researchers seek to understand human responses to abrupt environmental change. The vibrant state of geoarchaeological research and the global reach of the geoarchaeological community owe much to the solid foundations that Jack Donahue and his editorial board put down in the early years of the journal (Figure 4).

Figure 4: Jack Donahue, an archaeologist, then based in the Department of Anthropology at the University of Pittsburgh, was the founding editor of 'Archaeology: an International Journal',the first issue was published in January 1986 (source: by courtesy of Jamie Woodward).

During the last decades we witnessed an explosive increase in the development of technical tools: (1) affordable high definition *satellite imagery* (a.o. 'Google Earth'); (2) *drones*; (3) Global Positioning System (*GPS*), a satellite-based radionavigation system allowing a very precise location (Figure 5); (4) Light Detection and Ranging (*Lidar*), a remote sensing method based on laser technology used to examine the surface of the Earth and a.o. to produce very detailed digital elevation models (Figure 6);(5) Ground-penetrating radar (*GPR*), a geophysical method using radar pulses to image the subsurface (Figure 7); (6) *Magnetometry*, a technique studying variations of the Earth's geomagnetic field (Figure 8); (7) *Electrical resistivity sounding*, based on the estimation of the electrical conductivity or resistivity of the soil, an estimation based on the measurement of voltage of an electrical field induced by distant grounded electrode**s** (current electrodes) (Figure 9); all three geophysical techniques are non-intrusive methods of surveying the sub-surface, allowing archaeologists to "see" into the ground and identify what lies beneath the soil without having to perform very expensive excavations (Figure 10); (8) *Geographic Information System* (GIS), a system creating, managing, analysing and mapping all types of data; GIS connects data to a map, integrating location data (where things are) with all types of descriptive information; (9) *3 D-visualization,* creating graphical content by means of 3D software (Figure 11); (10) Optically Stimulated Luminescence *(OSL)* dating, providing a measure of time since sediment grains were deposited and shielded from further light; unlike C-14 dating no organic material is needed and the datable time span is much longer.

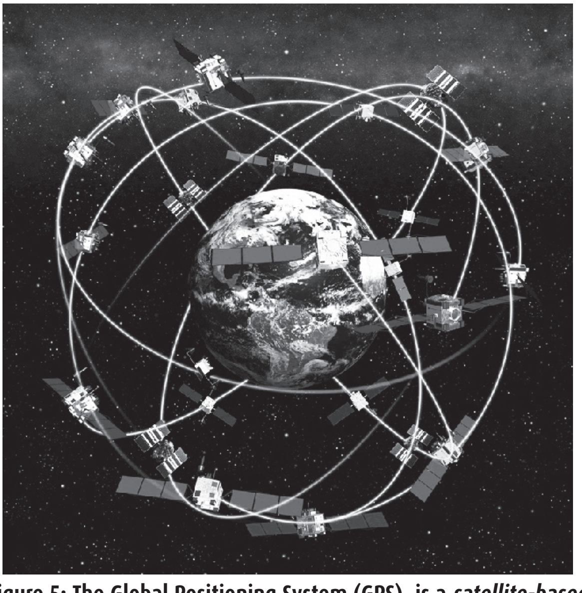

Figure 5: The Global Positioning System (GPS), is a *satellite-based radionavigation* system owned by the United States government and operated by the United States Space Force. The first satellites were launched in 1978. There are now 32 satellites in orbit (source: Wikimedia Commons).

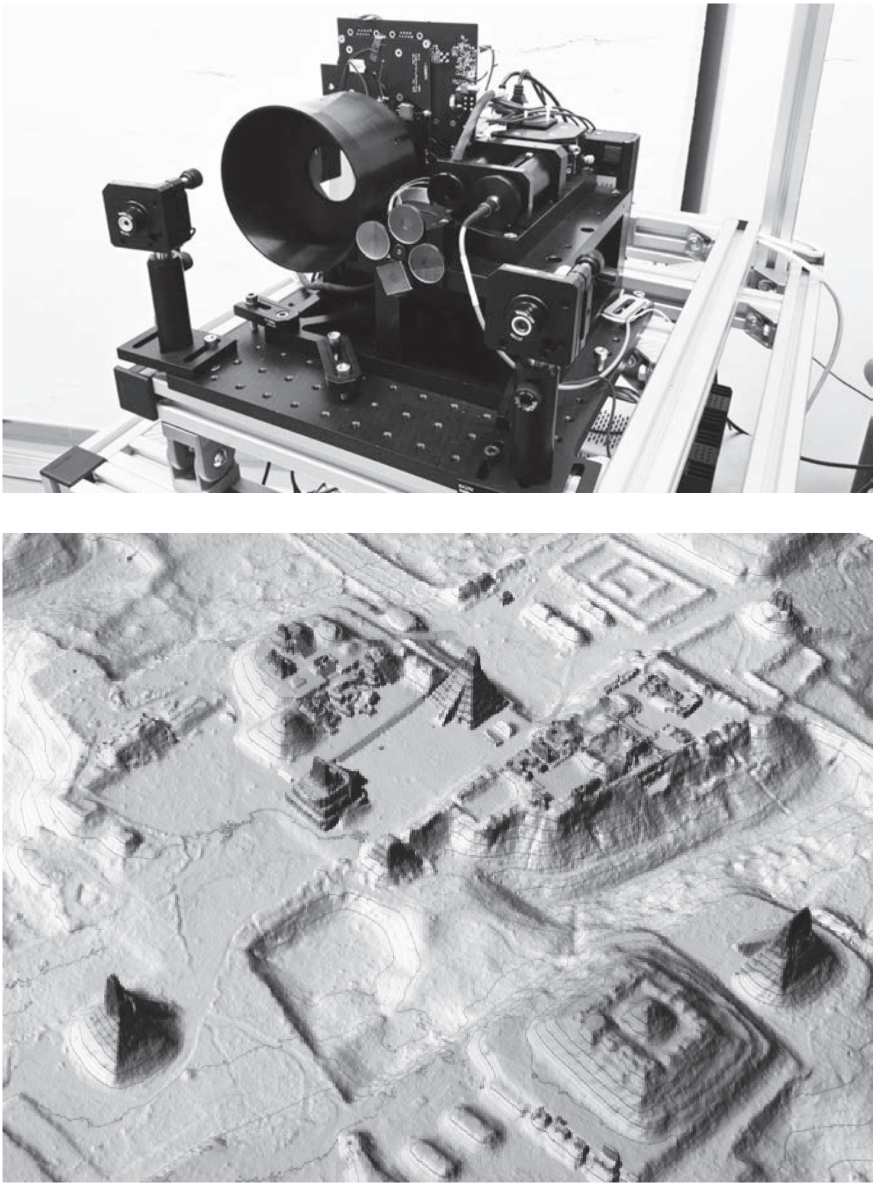

Figure 6: Above: Lidar-device. Below: using a Lidar mounted on a drone to detect Mayan ruins below a dense forest cover (source: Wikimedia Commons).

Figure 7: GPR uses radar pulses to image the subsurface (source: M. De Dapper).

Figure 8: Magnetometry detects variations of the Earth's geomagnetic field (source: M. De Dapper).

Figure 9: Electrical resistivity sounding is based on the estimation of the electrical conductivity or resistivity of the soil (source: M. De Dapper).

Figure 10: The geophysical techniques are non-intrusive methods of surveying the sub-surface, allowing archaeologists to "see" into the ground and identify what lies beneath without having to perform very expensive excavations. In this example we see the detailed street pattern of the Roman harbour town of Potentia (Marche, Italy) (source: by courtesy of the Potenza Valley Project).

Figure 11: Combining all results of the field research in a GIS it is posssible to construct a 3D-visualization. In this case a a bird's eye view on the Roman harbour town of Potentia (Marche, Italy) (source: by courtesy of the Potenza Valley Project).

In the last decades many handbooks have been published focusing on specific topics or regions (see appendix).

At the same time many scientific societies have founded special interest groups. The 'Geoarchaeology Working Group' of the 'International Association of Geomorphologists (IAG)' has now been active since 1995 and holds regular workshops, field meetings, and international conferences. The 'Society for American Archaeology (SAA') has a very active 'Geoarchaeology Interest Group'. They state: "Although many universities offer both archaeology and geology courses, few offer a coordinated, combined program. Yet most do have all the essentials for a geoarchaeology program, if simply the cross-links were emphasized. The geoarchaeology interest group will help students determine exactly what graduate and undergraduate courses are available in various universities leading to some training in geoarchaeology.". For German-speaking countries the 'Arbeitskreis Geoarchäologie' is operational since 2004. In 2022 the group published the first German handbook on geoarchaeology (cf. list).

Geoarchaeology programs remain common in geography, geology, and archaeology departments at colleges and universities. The environmental and cultural resource management firms and government agencies are increasingly hiring personnel with geoarchaeological experience.

We anticipate that the discipline will continue to grow, providing greater insight into our collective past while finding increasing relevance to current social and environmental challenges where deep time perspectives of human adaptation and ecological change are beneficial.

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Appendix. Handbooks on geoarchaeology (ranked by date of publication)

VERMEULEN, F. & DE DAPPER, M. (eds.). 2000. Geoarchaeology of the Landscapes of Classical Antiquity/ Geoarchéologie des Paysages de l'Antiquité Classique., Stichting Babesch: 233 pp.

GOLDBERG, P. & MACPHAIL, R. 2006. Practical and Theoretical Geoarchaeology. Wiley-Blackwell: 468 pp.

DE DAPPER, M., VERMEULEN, F., DEPREZ, S. & TAELMAN, D. (eds.) 2009. – "OL'MAN RIVER".

Geo-archaeological Aspects of Rivers and River Plains. - Archaeological Reports Ghent University – ARGU 5, Gent, Academia Press Scientific Publishers : 627 pp.

HOLDAWAY, S. & FANNING, P. 2014. Geoarchaeology of Aboriginal Landscapes in Semi-Arid Australia. CSIRO Publishing: 224 pp.

CANTO, M. 2015. Geoarchaeology. Using earth sciences to understand the archaeological record. Historic England: 64 pp.

GILBERT, A.S. (ed.). 2016. Encyclopedia of Geoarchaeology. Springer: 1046 pp.

CORDOVA, C. 2018. Geoarchaeology, the Human-Environmental Approach. Bloomsbury Publishing: 320 pp.

TRISTANT, Y & GHILARDI, M, (eds). 2018. Landscape Archaeology. Egypt and the Mediterranean World, IFAO, Bibliothèque d'Etude, 169: 296 pp.

STOLZ C. & MILLER C., 2022. Geoarchäologie, Springer, Heidelberg: 446 pp.

Laudatio M.Vandenbroeck

Ann Buysse

The Faculty of Psychology and Educational Sciences has unanimously proposed to the Sarton Committee to award the medal to colleague Michel Vandenbroeck for his exceptional merit for the study of history in the field of family pedagogy.

This merit is reflected in his academic work, his teaching and his social service. Michel Vandenbroeck has many publications to his name, is an esteemed teacher and is often consulted as an expert by policy makers, also within our own institution.

I would like to take you through some of the books Michel has written, which clearly show his merits. In addition to many articles, he has written three Dutch books "In verzekerde bewaring", "De Staat van het Kind" and "Het Gezin is dood" and two English books "Constructions of Neuroscience in Early Childhood" and "Problem Posing Early Childhood Education".

The ideas developed there – which also appear in many journal articles – make it clear how the study of the history of science and especially the history of thinking about young children and families provides a better understanding of contemporary pedagogical issues.

In the book "In verzekerde bewaring. Honderd vijftig jaar kinderen, moeder en kinderopvang" he outlines the history of childcare in Belgium from the establishment of the first day-care centres until around the last turn of the century. Much attention is paid to how science thinks about the importance of the child in different eras and especially how scientific evolutions – such as the evolutions in medical, developmental psychological and pedagogical thinking – relate to social, political and economic evolutions.

In the book "De staat van het kind. Het kind van de staat", this is elaborated by means of themes whose history is described. In this way, this work becomes a genealogy of pedagogy, in which the history of science is a means to reflect on contemporary scientific evolutions. The contemporary research themes whose history is described are highly relevant in the context of many social debates and include motherhood, the quality of early childhood education, processes of inclusion and exclusion (Matthew effects), dealing with diversity, and professionalism.

The third book, "Het gezin is dood. Leve het gezin", outlines the history of family pedagogy in general and the recent history of parenting support in particular. It addresses the question of how the emergence of a new paradigm with a new scientific vocabulary around the end of the 20th century – think for instance of parenting support or empowerment – can be explained and how these scientific developments can be related to social and economic developments and changes in attitudes towards the welfare state.

The ideas from these three books are also contained in a number of international publications, including English books, journal articles and many international lectures. It is because of that analysis of the relationship between pedagogy as a science and broader social developments that Michel Vandenbroeck already received 2 honorary doctorates: from Tampere University in 2018 and from Uppsala University in 2020.

The common thread running through Michel's publications is that the study of history is a way of making what seems strange familiar and thus questioning what seems familiar. And this by showing that history is made by people and can therefore be changed.

The study of the history of pedagogy shows that what we consider "in the best interests of the child" today is a construction that cannot be separated from the social context. And thus that a reflection on pedagogy as a science always includes a critical social reflection.

The difficult relationship between educational advice and educators. A historical and social narrative

Michel Vandenbroeck

A genealogy of educational advice

In 2000, Judy DeLoache and Alma Gottlieb published a funny, but also interesting book: *A world of babies*. Seven chapters in that book are written as if world famous experts on education were their authors, including Benjamin (dr) Spock, Penelope Leach and Barry Brazelton. But DeLoache and Gottlieb pretended these authors did not live in the Global North, but among the Fulani or the Beng people in West-Africa, in a tiny rural village in Turkey, in Bali, among the Warlpiti in Australia or the Ifaluk in the Pacific. The result is most amusing, but it also created the insight that what is good for children, what is in their best interest, and this what advice to give to parents, can substantially differ from time to time and from place to place. In the foreword to the book, Jerome Bruner writes:

> I have always harboured the view that child rearing is a human activity fraught with so many emotional and social dilemmas, so many projective possibilities, and such grave physical consequences and strokes of fate (in many parts of the world, the infant mortality rate is still extremely high) that its practices and our beliefs about it are particularly liable not only to cultural shaping but also reshaping (p. xi).

The present contribution aims to deal critically with the impact of science on parenting advice and on our image about what is in the best interest of the child. We therefore look at science as a construction of Truth, a discourse about Truth. We look at changing perceptions about how we think about children, on how we think about the relations between families and the state, and how we think about the very meaning education in general and of early childhood education in particular.

We deliberately write Truth with a capital T. In doing so, we wish to highlight that Truth, as the concept is used here, is not an objective fact, but a construction, a way of seeing, and thus – inevitably – a way of not seeing (Burke, 1984). It needs to be clear that the objective of this chapter is neither to criticise the claims made by science, nor to amend the progress that scientists have made in understanding children and their education. Neither has this chapter any intentions to criticise the people who call themselves scientists, nor the scientific methods they use. Nevertheless, the intention is to offer a critical look at how the sciences are popularised for advocacy reasons, and how sciences are used to make political claims (about what equal opportunities mean for instance); or how they are misused, narrowing the meaning of early childhood education (as a machine for early learning for instance) and parenting (as a series of skills for instance).

Such a critical stance can help to reflect on how Truth claims have become dominant so that it is now difficult to look at children and early years' policies outside of the dominant economic paradigm. In sum, the aim is to criticise how in a certain socio-political context, a specific form of Truth about early childhood emerges, how the use of science plays a crucial role in such constructions, and how these regimes of Truth – in turn – also shape specific power relations that render children and parents into objects of intervention.

Eventually, we also wish to criticise the democratic deficit of such Truth constructions in the sense that they also influence and are influenced by specific power relations (Foucault, 1993, 2001).

A short paradigmatic note

The central Foucauldian question is not what power is, but rather where does it come from and how does it operate. Power, for Foucault, is less repressive than it is productive (Deleuze, 1985):

> One needs to acknowledge that power relations produce knowledge (and not only because they favour knowledge for its practical use), that

> power and knowledge are mutually linked, and that there is no power relation without the construction of a field of knowledge, nor is there knowledge that does not supposes and constructs power relations (Foucault, 1975, p. 36. Translation by us)[1].

Power produces educational practices by determining how problems are constituted, how people are classified and what are considered appropriate ways to shape behaviour (Moss, Dillon, & Statham, 2000). Popkewitz (1996) argued therefore that pedagogy is a specific site, which relates political rationalities to the capabilities of the individual. This is very much in line with the view of Paulo Freire (1970, p. 152) who stated: "The parent-child relationship in the home usually reflects the objective cultural conditions of the surrounding social structure". What these authors refer to is that what we believe to be the Truth about early childhood education is always contingent with the wider social and political context. We need to analyse how, historically, early childhood education has been framed as a solution to a socially constructed problem (Vandenbroeck, Coussée, & Bradt, 2010). Visions about what is good for children, what are parental responsibilities, when states need to interfere, and what is the very meaning of early childhood are indeed not a-historical, and neither are the sciences that inform them. As a result, it is important to understand the constructions of science in early childhood education in their historical dimensions. This calls for a *genealogical* approach, meaning, according to Foucault (2001a, p. 1493):

> "I start from how a problem is presented in the present and try to make the genealogy of it. So what I try to do is to make the history of relations between thought and truth, a history of thoughts, in the sense that it constitutes a history of truths"[2].

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1 Il faut plutôt admettre que le pouvoir produit du savoir [...], pouvoir et savoir s'impliquent directement l'un l'autre; qu'il n'y a pas de relation de pouvoir sans constitution corrélative d'un champ de savoir, ni de savoir qui ne suppose et ne constitue en même temps des relations de pouvoir. [...] Mais il ne faut pas s'y tromper: on n'a pas substitué à l'âme, illusion des théologiens, un homme réel, objet de savoir, de réflexion philosophique ou d'intervention technique. L'homme dont on nous parle et qu'on invite à libérer est déjà en lui-même l'effet d'un assujettissement bien plus profond que lui. [...] Cette âme [...] est l'élément où s'articulent les effets d'un certain type de pouvoir et la référence d'un savoir, l'engrenage par lequel les relations de pouvoir donnent lieu à un savoir possible, et le savoir reconduit et renforce les effets du pouvoir.

2 Je pars d'un problème dans les termes où il se pose actuellement et j'essaie d'en faire la généalogie. Généalogie veut dire que je mène l'analyse à partir d'une question présente. […] Ce que j'essaie de faire, c'est l'histoire des rapports que la pensée entretient avec la vérité; l'hisotire de la pensée en tant qu'elle est pensée de la vérité

As Escolano (1996) claimed in a seminal paper on a hermeneutical approach of the history of education, this stance asks for an evaluation of the internal coherence of the organisation of data and discourse and their external coherence with the social context and with other concordant or discordant stories. This chapter will very briefly do so for two periods in the history of early childhood education: the early 20th century and the constructions of prophylaxis and eugenics; and the post Wold War II period with the constructions of attachment and developmental psychology, before turning to the present and the constructions of neuroscience. So, once again, when we look at – for instance – the use of prophylactic knowledge gathered by Pasteur, Koch or Lister at the turn of the previous century or the theories of Bowlby and Gesell after World War II, the aim is not to challenge this knowledge or criticise the validity of the claims that were made. Nor do we wish to make a judgement on their intentions. Rather the aim is to contribute to our understanding of how, in a specific socio-political context, these sciences became dominant and how they were shaped and contributed to shape power relations in the field of the early years. In so doing, we hope to shed some light on change and continuity in the present era.

To warrant, for the country, a strong and beautiful race[3]

The first period we briefly sketch is the beginning of the 20th century: a period that marked the origins of organised day care in many European countries (Vandenbroeck, 2003). It was a period in which a huge gap between the bourgeoisie and the emerging labour class existed, due to extremely low wages and poor living conditions of the latter (Scholliers, 1995). It was just impossible for a family to feed more than one child with one income and the living conditions of labour families were less than poor, even according to the then prevailing standards (Lafontaine, 1985). The early 20th century was also marked by a rather harsh liberal welfare state, since it was consensual – at least among the bourgeoisie, the only citizens who had the right to vote – that the State should not intervene in private matters. As a result, there were no such social measures such as sickness leave, paid maternity leave, allowances or health insur-

[3] From a speech by Elise Plasky on 5 February, 1910 in which she tried to convince decision makers to build more crèches (Plasky, 1910)

ances. It does not come as a surprise that child mortality was very high: 15 to 25 % of children did not live up to their first birthday (Plasky, 1909; Poulain & Tabutin, 1989). Both the living conditions and child mortality were sources of social uproar that challenged the social order and led to the creation of labour class movements in most industrialised cities, and subsequently to the use of strikes as a political weapon. As a result, child mortality was a rising source of concern for the leading class as well. Three scientific disciplines helped to frame this child mortality problem and to construct it as a pedagogical problem that needed intervention: statistics, eugenics and prophylaxis. The statistical sciences were originally considered as an art of governing (Fendler, 2006) and gained scientific status in this period. In the first governmental report on child mortality in Belgium, for instance, many statistical analyses were used to exclude weather conditions as a possible cause for child mortality, as well as other potential causes, and eventually to frame the problem as a problem of labour class neighbourhoods (Velghe, 1919). Inspired by the evolutionary biology of Darwin, social Darwinism (e.g. Spencer) and the neo-Malthusians (Williams, 2000), the eugenic sciences were considered as a leading source of knowledge on the importance of building a strong race for the recent nation states. As an example, the prestigious scientific Solvay institute established the Belgian Office for Child Welfare in Brussels in 1922 (Nationaal Werk voor Kinderwelzijn, 1922). It is probably not a coincidence that the attention for a strong race occurred in a period of industrialisation where health was increasingly perceived as an important economic good (Foucault, 1975). Supported by the eugenic turn, child mortality became a state affair and an object of policy making. The premature death of a child was now not only considered as an offence of the mother towards her child, but also as an offence of the mother towards society as a whole. The new prophylactic sciences (e.g. Louis Pasteur in France, Robert Koch in Germany or Joseph Lister in England) had indeed discovered the origins of infectious diseases, as well as ways to prevent them. And with this new knowledge came a large offensive to civilise the labour class and to inform working class mothers about the new prophylactic wisdom, resulting in the mushrooming of charity initiatives such as infant consultation schemes and crèches (Vandenbroeck, 2006). These institutions often also had an implicit aim of soothing the discontent of the labour class. Their civilising function was even quite explicit in Marbeau's much used handbook for the bourgeois charities that wished to initiate child care in France and beyond. In the chapter about the eventual opening of the crèche, Marbeau (1845, p. 91) wrote:

> "The poor mothers await this day like the arrival of the Messiah. A touching ceremony will show the indigent that the authority, seconded by the rich, watches over the children with maternal kindness; and the holy bells announce to the poor that one cares for him and to the rich that he has to give" (Translation by us) [4].

It is an eloquent example of what Freire (1970, p. 44) wrote on charity:

> Any attempt to "soften" the power of the oppressor in deference to the weakness of the oppressed almost always manifests itself in the form of false generosity; indeed, the attempt never goes beyond this. In order to have the continued opportunity to express their "generosity", the oppressors must perpetuate injustice as well.

In sum, statistics framed the social problem of child mortality as a labour class problem; eugenics legitimated State intervention in a liberal – and thus non-interventionist – welfare state, whilst the prophylaxis explained how the problem needed to be solved. As a result, this scientific Truth contributed to construct the causes of child mortality as either the neglect of culpable mothers, or their ignorance, labelled as 'stupid prejudices' of mothers who did 'not even read the brochures we distribute to them' (Velghe, 1919). In reality, many of these mothers lacked the means to follow the advice, considering that, for instance, the wood or the coals that were necessary to sterilise the dummy-teats were unaffordable for them. The solution of the social problem – which was in the meantime translated into an educational problem – was believed to be provided by philanthropic provision that was based on charity and thus on a moral of the social order, not on civil rights. It is a typical illustration of how a social problem was politically framed as an individual problem and how science was (mis) used to legitimise this individualisation of responsibility.

[4] Les pauvres mères attendent ce jour comme le Messie. Une cérémonie touchante fait voir aux indigents que l'autorité, secondée par les riches, veille sur leurs enfants avec une sollicitude maternelle, et la cloche sainte annonce au pauvre qu'on pense à lui, annonce au riche qu'il faut donner.

The steady growth of evidence

> Among the most significant developments of psychiatry during the past quarter of a century has been the steady growth of evidence that the quality of the parental care, which a child receives in his earliest years is of vital importance for his future mental health (Bowlby, 1953, p. 13).

This quote from John Bowly, psychiatrist and "founding father" of the attachment theory, is eloquent of the modernist believe in science as progress. After the Second World War, affluent societies were marked by an impressive optimism in the future and an unwavering belief in science as the pathway to welfare and happiness. It was the period in which more democratic – rights-based – welfare states were emerging (including general voting rights, social security, minimal wages etc.) in most European countries. From the 1950's to the 1970's economies were prosperous, unemployment was historically low and – together with social security and other protective measures – it resulted in a dramatic decrease of poverty and child mortality, at least in affluent European countries. As an example: while child mortality in Belgium was still around 10 % shortly after WW II, it was only around 2 % in 1968 (Nationaal Werk voor Kinderwelzijn, 1970). The latter caused serious legitimation problems to the vast *dispositif5* of child welfare organisations throughout Europe. It was developmental psychology, starting with attachment theory, that took over the prescribing role of the prophylactic sciences. The World Health Organisation (1946) broadened her definition of health to also include mental and social well-being and in doing so it broadened its definition of health as "not merely the absence of infirmity". As a result, the entire population – both healthy and unhealthy – became a potential target for preventive measures. One example of this is the massive introduction of the Apgar score in the 1950's, giving a first assessment report to all new-born children on a 10-point scale. Another salient example is the rapid popularisation of the attachment theory. First developed by John Bowlby on behalf of the WHO, it was soon *naturalised* by Harlow (1958) and his experiments with monkeys and cloth mother surrogates. What Harlow essentially did, was to demonstrate that attachment and the basic need of the young child

[5] Foucault uses the term *dispositif* to designate a heterogeneous assemblage of discourses, institutional regulations, scientific statements, political propositions, even architectural designs, etc that are not necessarily contingent, but that together have a strategically dominating function (which is not the same as saying that they have a dominating goal or are purposefully designed as an assemblage) (Foucault, 2001b, p. 298-299).

for maternal love were simply natural: an indisputable part of both human and animal nature. In the 1970's Mary Ainsworth (Ainsworth & Bell, 1970) further completed the work and gave it an even more indisputable stance by making attachment measurable, categorisable and thus even more scientifically True. With the Strange Situation test, she developed a diagnostic instrument that aimed at distinguishing the normal from the pathological. The work of Bowlby, Harlow and Ainsworth offer some examples of the rapidly growing discipline of developmental psychology and the proliferation of developmental tests, monitoring and screening methods that contributed to a new understanding of normality. In that sense, it can be argued that developmental psychology functioned as what Foucault (1975) described:

> The exercise allows a perpetual characterisation of the individual, either compared to the norm, compared to other individuals, or compared to the type of trajectory. […]
>
> The perpetual penalty running through all points and controlling all moments of the disciplinary institutions compares, differentiates, hierarchizes, homogenises and excludes. In sum, it *normalises* (Foucault, 1975, p. 189; 215. Original emphasis; translation by us)[6].

Developmental psychology in general and attachment theory in particular have been the subjects of severe criticism since the 1990's, including from feminist theorists (Burman, 1994; Canella, 1997; Singer, 1993). It is indeed probably not a coincidence that the earlier versions of attachment theory – urging mothers to take care of their child in the home – gained momentum after the wars, when women were no longer wanted in the industry and it was considered that women better returned to their traditional bourgeois roles. Neither is it probably a coincidence that the attention for cognitive development increased in the period of the Cold War. Indeed, after the Sputnik shock (Martens & Niemann, 2010) the West was afraid to lose the race to space and increasingly became aware that nation states could hardly afford not to exploit the full intellectual potential of their populations. What is of concern here is how developmental psychology contributed to change the views on children. The metaphor of developmental phases, introducing the image of the child climbing stairs, and the adulto-centric nature of this metaphor orig-

6 L'exercice permet une perpétuelle caractérisation de l'individu soit par rapport à ce terme, soit par rapport aux autres individus, soit par rapport à un type de parcours. La pénalité perpétuelle qui traverse tous les points, et contrôle tous les instants des institutions disciplinaires compare, différencie, hiérarchise, homogénéise, exclut. En un mot elle *normalise*.

inated from this period and were here to stay. According to this new science, each phase in the child's development builds on the former and thus, when something causes concern, the problem needs to be analysed in relation to what went wrong in the previous stage. The succession of developmental stages is perceived, according to this Truth, as a steady evolution towards the better, the stronger, and the more intelligent, with the adult as its apogee. Together with this metaphor, measurable norms appeared about what a child should be able to do at what age, accompanied by an implicit understanding that the sooner was also the better in a kind of Olympic Games – citius, altius, fortius – of development. Consequently, this new knowledge led to the discovery of the baby and a renewed focus on the early years, as it is during the early years that the foundations of development are built.

The Sputnik shock, as well as the pressure from the civil rights movements, gave rise to new educational programs in the U.S. (and later in Europe) for what were then called "disadvantaged children" (Beatty, 2012; Beatty & Zigler, 2012). After a first few years of euphoric scientific news, the results were more disappointing as it became clear that the expected benefits did not last much longer than the programmes. In line with the developmental approach, it was argued that this supposed failure was due to the fact that interventions came too late and thus initiated a plea to be more concerned with early education, framing the preschool as a preparation for school. Interestingly, the supposed failure of Head Start projects was in the early 1970's also used to legitimate the political decision to shift the attention from the public to the private sphere, and to focus more on interventions in the family (Beatty & Zigler, 2012). Accordingly, there was a growing consensus in the scientific community that a stronger focus on the role of the "disadvantaged" parent was needed. Uri Bronfenbrenner was one of the leading critics of the early compensation programs and advocated for broadening the programmes and rendering parents into objects of intervention:

> […] The relations between parents and children should be reinforced […] The learning of the child will then be enhanced, and so eventually a more stable interpersonal system will develop, that will be able to foster the development of the child and ensure its future (Bronfenbrenner, 1974, p. 25. Translation by us)[7].

[7] […] daß sich die Bindungen zwischen den Eltern und dem Kind verstärken […] daß zich dadurch das lernen des Kindes gefördert wird, und daß schließlich ein stabiles interpersonales Systeem entsteht, das imstande ist, die Entwicklung des Kindes zu fördern und für die Zukunft zu sichern

In sum, after a period in which the problem of child mortality was "solved", developmental psychology gave a new legitimation to the concern for labour class families – or the *Negro Family*, as they were called in the Moynihan report (Beatty & Zigler, 2012). Parents were now supposed to be the lay teachers of their children, which has been labelled as the pedagogicalisation of parents (Popkewitz, 2003) – or even better: mothers. Again, the focus was rather on maternal responsibility than on the shared responsibility between the public and the private domains. Burman (1994) quotes the early work of Gesell (1950) to illustrate this focus on the mother's responsibility: "It is as if the nervous system of the child is completed by the mother. It is her role to think ahead for the child". In the context of the cold war, the political attention for the educational gap gained momentum. Again, however, the educational gap was not framed as a societal problem of inequality, but rather as a "socio-cultural handicap" of individual families (De Landsheere, 1973). The scientific field shifted its attention from the medical to the psychological. Yet, the use of this scientific field to frame specific families as objects of intervention, without including the families in the debates of what their alleged problem was, did not significantly change.

Third Way politics in times of crisis

The entire period from the late 1970's to the present is marked by consecutive economic crises and rather brief intermediate, slightly more prosperous, intervals. In the late 1970's, the oil crisis caused unemployment, dislocation of industry to low-wage countries, and lasting budgetary problems for all affluent nations. It has hardly changed until and beyond the banking crisis at the beginning of the 21st century. It is an era marked by globalisation: events that happen thousands of miles away have direct influence on the intimacy of our daily lives. The explosion of the nuclear plant in Chernobyl in 1986 directly affected the food of millions of families in Europe; the developing Chinese economy raised oil prices in Europe; and the irresponsible greed of U.S. and European bankers influenced the home situations of millions of citizens worldwide. It is the era of the "new social question" (Lorenz, 2005): the growing idea that nation states fail in protecting their citizens against unemployment, poverty and other matters. Rosanvallon (1995) argued that the end of the twentieth century was marked by a triple crisis: a financial crisis (states were faced with increased spending in social security issues such as unemployment benefits, while facing reduced income); a bureaucratic crisis (states being increasingly perceived as ineffective and inefficient by the general population as well as by policy makers); and a philosophical crisis (raising questions about the very concept of social welfare and social security). It is well documented how this crisis gave fertile grounds to what has been labelled as "Third Way politics": alleged consensual policies with a growing focus on risk-management, individual responsibility and a discourse of 'no rights without duties' (Vandenbroeck et al., 2010). Different names have been given to the profound changes in the welfare state organisation that these policies engendered, such as 'the 'employment first welfare state' (Finn, 2003) or the 'contractual state' (Crawford, 2003). Among the many different aspects of this era, there are three characteristics that we wish to bring to the fore, in order to understand the prevalence of econometrics and neurosciences in early childhood education in present times: everything must be consensual; everything must be economical; and the layperson is unable to see.

Everything must be consensual

Typical for Third Way politics is the search for consensual rather than conflicting policies. The Third Way was developed as the one single possible answer to contemporary societal challenges and policies had the ambition to overcome the disputes between the political left and the political right (Mouffe, 2005). The slogan that summarises this could be TINA (There Is No Alternative). The core idea of "no rights without duties" and the contingent shift from welfare to justice (Wacquant, 2002) was not only a matter of policy makers, but was in many instances co-constructed by social work itself (Bradt, 2009). It is reflected in the shift of policies from combating poverty to combating child poverty. As analysed by Morabito, Roose and Vandenbroeck (2013), a shift occurred from redistributive policies (e.g. through taxation, social welfare) aiming at equality of outcomes to policies aiming at equality of opportunities. The World Bank advocated it as a consensual policy:

> The idea of giving people equal opportunity early in life, whatever their socioeconomic background, is embraced across the political spectrum – as a matter of fairness for the left and as a matter of personal effort

> for the right. […] Thus, shifting the debate from inequality of income or earnings to inequality of opportunity, and to the policies needed to tackle that inequality, might facilitate a political and policy consensus. When the focus of the debate is on inequality of income or any other outcome, the views about how much to redistribute – if any at all – and through which mechanisms would vary from left to right across the political spectrum. However, when the focus shifts to the equalization of opportunity, political consensus about the need to reduce inequity is easier to achieve, and the direction this principle gives to policy is clearer (Paes de Barros, Ferreira, Molinas Vega, & Saavedra Chanduvi, 2009, p. xvii; 27).

As a result, early childhood education comes into the picture as the potential and consensual solution to many social problems. Indeed, while state intervention in the redistribution of outcomes is increasingly considered as problematic, interventions in early childhood education cannot be suspected of benefiting the "undeserving poor". No one can blame the child for being poor, can one? Early years investments are promoted as being the greatest potential equaliser, by both international organisations such as UNESCO (see Morabito et al., 2013 for some examples), and policy makers. In his report on combating poverty to the British Government, Frank Field (2010, p. 5) wrote:

> It is family background, parental education, good parenting and the opportunities for learning and development in those crucial years that together matter more to children than money, in determining whether their potential is realised in adult life.

There is a remarkable resemblance to be noticed with a 19th century handbook for bourgeois charity stating: "of all causes of indigence, education is the most important" (de Gérandot, 1820, p. 12. Translation by us)[8].

Everything must be economic

Despite the fact that nation states have less impact on their national economies in the global market – or maybe because of that – all policies have a particular focus on economic aspects. It also affects what previously was called the "non-profit sector" and renamed itself after the first economic crisis as

8 De toutes les causes de l'indigence, c'est l'éducation la plus importante.

the "social profit sector", thus adopting an economic discourse and contributing to the marketisation of the social. The dominance of economic issues obviously also affected early childhood education. Firstly, it was noticeable by an increasing commodification and marketisation of early childhood education, based on the assumptions that markets enhance competition and thus warrant quality and economic efficiency (for a thorough critic of these assumptions, see Vandenbroeck, Lehrer and Mitchell, forthcoming). Secondly, the commodification is also noticeable in the ways in which early childhood policies are increasingly discussed with economic arguments, including the famous "return on investment" argument (e.g. Barnett & Masse, 2007). It is hard, nowadays, to find a policy document on early childhood education that does not quote Nobel Prize laureate James Heckman, often also including his famous "Heckman equation", illustrating that investing in the youngest children allegedly yields the highest economic returns (Heckman, 2006). There seems to be little criticism about the very idea that social and educational policies are primarily justified in pragmatic economic terms and that democratic and value-based arguments seem to have disappeared from the public debate (Moss, 2007; Mouffe, 2005).

The layperson cannot see

Shortly after the nuclear disaster in Chernobyl, Ulrich Beck (1987) wrote an interesting essay on the "anthropological shock" this caused. He explained that the urgent warning the next day, that one should not let one's children play in the sandbox was followed by the unverifiable denial that this recommendation had any validity whatsoever. What Chernobyl did to society, Beck explained, was that danger and its consequences became invisible. While experts contradicted each other on television, this "deprivation of our senses" provoked the paradoxical reaction that laypersons became even more attracted to and dependent of the experts' opinions (Beck, 1987). Rose and Abi-Rached made a very similar claim when it comes to the 'imaging business' of neurosciences:

> We, the laypersons cannot see. We need the designation of those who have the authority to see, including the imagers. […] To render visible, that is to say, requires conditions of possibility within a larger, networked, distributed, assembled field of intensities and powers – connecting up such diverse sites as the clinic, the lab, the pharmaceutical

> company, popular literature, and the mass media. […] The image, despite suggestions to the contrary, and despite all the arguments black-boxed within it, does not speak for itself – it has to be spoken for. (Rose & Abi-Rached, 2013, pp. 55-56)

This brings us to the core of the argument: the current status of the neurosciences and their use in social and educational policies.

The progressives' faith in technical expertise for solving social problems9

> The foundations of brain architecture are established early in life through a continuous series of dynamic interactions in which environmental conditions and personal experiences have a significant impact on how genetic predispositions are expressed (National Scientific Council on the Developing Child, 2007, p. 1)

Since the turn of the millennium the neuro-argument about early childhood education is prevailing, raising the expectation that the neurosciences will explain it all (De Vos & Pluth, 2016). Neurosciences and brain images are increasingly popping up in documents of policy makers, but also of NGO's, advocating for investments in the early years. A typical example is the report on early intervention by MP Graham Allen to the British Government (Allen, 2011). The Allen report showed the much-abused image of a shrunken "nutshell" brain on its cover, insinuating that a lack of care in the early years would cause such a deteriorated brain. The report argues that considering the rapid growth of the brain in the first two years, we can realise

> "reaping massive savings in public expenditure for the smallest of investments in better outcomes, and by avoiding expensive provision when things go wrong" (Allen, 2011, p. vii).

A few years later, in a paper advocating "Social Impact Bonds, Allen (s.d.) argued that early years interventions are too challenging for the public sector, yet – considering that long term returns on investment are proven – they should be privately financed and the latter would promote competition and thus drive innovation. Another example is the report that MPs

[9] It is a quote from William T. Gormley in *Science*, arguing – without any ironic twist – that (neuro) scientists should be more proactive in influencing policy makers (Gormley, 2011, p. 978)

from different parties wrote, urging the British government to invest both in antenatal classes and in "evidence-based services" for "at-risk families" in the first "critical 1001 days" as that restricted period is believed to be a key moment for brain development, because:

> We know too that not intervening now will affect not just this generation of children and young people but also the next (Leadsom, Field, Burstow, & Lucas, 2010, p. 2).

The use of this nexus of brain research and economic arguments is not just the privilege of policy makers. It is also used by NGO's. An example is the brochure with the title "Lighting up your brains", published by Save the Children. The brochure argues that brain research has shown that parents need to enhance the "Home Learning Environment" (and it spells out what behaviour parents need to deploy "to help build your child's brain"), next to a plea for high quality nurseries (Finnegan & Lawton, 2016). The document frequently uses terms such as "wired in the brain", "brain architecture", "sensitive" or "critical periods" and "toxic stress", and we can increasingly find these terms in publications from international NGO's (e.g. Marope & Kaga, 2015).

That is of course no coincidence. Scholars from the National Scientific Council on the Developing Child (Harvard University) joined forces in a 7-years project with communication specialists (FrameWorks Institute) to "frame" brain research in such ways that it would influence policy makers and other lay people. Using different panels and interviews with lay people to examine which concepts would have most impact, the communication specialists came up with the following metaphors (or "frame elements"): "brain architecture", "toxic stress", "serve and return" and the image of the "circuitry" of the brain as best options for a "simplifying model" that could enhance policy impact (Shonkoff & Bales, 2011). The communication effort was the logical pursuit of a group of scholars who claimed that it was time for a "more robust Science-to-Policy Agenda" (Shonkoff & Leavitt, 2010, p. 690).

> The contribution of neuroscience to innovation in social policy could be formidable. Basic and clinical research over the past two decades have created a highly promising yet underdeveloped interface between these two worlds [neuroscience and social policy] that would benefit considerably from a more permeable boundary (Shonkoff & Leavitt, 2010, p. 691).

High-level scholarly journals in this field (e.g. Science) argued that policy makers "should champion the adoption and sustenance of legislation consistent with the findings of that research. They should translate good science into good public policy" (Gormley, 2011, p. 978). The article suggested that scholars should publish short texts (the average length of a successful policy brief in the US Congress being 2.91 pages) that describe consensus, since "research is less likely to be used, when there is no scholarly consensus" (Gormley, 2011, p. 979). What this may mean in practice, is illustrated by a much-cited brochure from the National Scientific Council on the Developing Child (2007, pp. 6-7):

> The basic principles of neuroscience indicate the need for a far greater sense of urgency regarding the prompt resolution of such decisions as when to remove a child from the home, when and where to place a child in foster care, when to terminate parental rights, and when to move towards a permanent placement. The window of opportunity for remediation in a child's developing brain architecture is time-sensitive and time-limited.

The citation makes perfectly clear how this form of Truth construction inevitably leads to the objectification of children and parents, an objectification that erases all space for dialogue. It reduces policy to the application of "scientific" advice, rather than as the organisation of antagonistic debate (Mouffe 2005). When science produces indisputable Truth and policies are reduced to its application, this presents the end of what Mouffe calls "the political".

This one-sided use of science and the accompanying simplified concepts have received much criticism, including from within the neurosciences. Much of this criticism is about the concept of critical periods that does not sufficiently take into account the plasticity of the brain (Blakemore & Frith, 2005; Bruer, 2011; Maguire et al., 2000; H. Rose & Rose, 2012). In addition, there have been serious methodological warnings about oversimplifications and even suspicious interpretations of results of fMRI and other visualisations of brain activity (Bennett, Baird, Miller, & Wolford, 2009; Bettis, 2012; Vul, Haris, Winkielman, & Pashler, 2009). Even though, the neurosciences have indeed made great progress in understanding the relations between economic adversity and brain development (Neville, Stevens, Pakulak, & Bell, 2013; Noble et al., 2015), the claim made by Bruer in 1997 that basing social policy on neuroscience is "a bridge too far", however, still holds.

Discussion

The constructions of science in early childhood education show some continuity through different historical periods. Today, considering the many ethical issues, as well as the methodological flaws, one could wonder why policy makers from both the left and the right – together with advocacy NGO's – are lured by the Sirens of neuroscience. One possible explanation is of course the alleged consensus on the shift from redistributive social policies to equality of opportunities, as described above. Another important aspect is that the use of brain images adds to the credibility of the message. Legrenzi and Umiltà, two renowned neuroscientists who often stood up against the misuse of neuroscientific arguments, narrate an interesting experiment conducted at Yale university showing that psychology students more readily judged a message as true, when it was accompanied by images of brain scans, even when these had nothing to do with the content of the message (Legrenzi & Umiltà, 2011). This may be attractive for frustrated activists who since several decades advocated – often in vain – for more attention for the early years, especially when faced with austerity policies that threaten to reduce the budgets for social and educational matters. It may indeed appear tempting to early years activists to argue that the investments in the early years pay off, and in so doing one can then justify ones profession. However, by using the neuro-economic argument of the return on investments, they inevitably reinforce the idea that the only argument that matters is indeed economic.

A most important aspect of the seductive characteristics of the brain argument is the historical continuity in viewing children as the object of policy, saving the world, one child at the time. Inevitably, the image of the fragile child as a future of the nation and the salvation narratives that go with it, frame parents as suspicious (Hendrick, 1997). The focus on parental deficits has even increased with the use of neuroscientific constructions, which is reflected in the proliferation of parent training programs and their discourse on parenting skills (Macvarish, Lee, & Lowe, 2015). It is probably not a coincidence that in times when man-made risks become incontrollable – be it ecological or economical – the mirage of the feasible child becomes even more attractive. As Furedi (2014, pp. ix-x) argued:

> When leading politicians on both sides of the Atlantic can argue that bad parenting harms more children than poverty, then it becomes ev-

> ident that parental determinism has become the mirror image of economic determinism.

This seems to be precisely what is at stake here: a neurobiological-economic nexus in which childhood is merely the preamble of adult productivity in a meritocratic society. Scholars of that nexus indeed warn us that:

> A growing proportion of the U.S. workforce will have been raised in disadvantaged environments that are associated with relatively high proportions of individuals with diminished cognitive and social skills. A cross-disciplinary examination of research in economics, developmental psychology, and neurobiology reveals a striking convergence on a set of common principles that account for the potent effects of early environment on the capacity for human skill development (Knudsen, Heckman, Cameron, & Shonkoff, 2006, p. 10155).

What we learn from this history of the present is that what is considered as True is not a-historical and what is considered as valuable and valid science is always related to the socio-political context. The context today is one in which the welfare state is much less considered as the necessary compensation for inevitable unfair effects of the free market, but rather as one of global capitalism in which welfare expenditures are constructed as avoidable inefficient threats to the free market. This has profound effects on the discussion on the very significance of education and pedagogy. While the meaning of education is narrowed down to issues of productivity, early childhood education risks being reduced to early learning. Early learning in itself, then, becomes a mere preparation for the real learning that takes place in compulsory school (Moss, 2013). In the same vein, pedagogy risks being reduced to the development of effective methods to achieve the predefined goals. Social pedagogy then is nothing more than an attempt to keep some attention for the relational – some would say holistic – aspects of this utilitarian pedagogy. In sum, pedagogy – including social pedagogy – is then reduced to the search for doing things right, while leaving out the question of what is the right thing to do.

When education is instrumentalised as the road towards a predefined goal that lies beyond childhood, this inevitably raises the question about who is entitled to define this goal. Who can participate in the debate about what early childhood education is for? And this is where the bio-economic nexus leaves no space for debate. It is the democratic deficit of “There-Is-No

Alternative”. This means that parents are reduced to “beings for others” in the Freirian sense. According to Freire (1970, p. 60) science and technology can be used to reduce men to the status of “things”; yet they can also be used to promote humanization, since the essence of education as problem posing education responds to the essence of consciousness, rejects communiqués and embodies communication.

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Laudatio Harry Van Leeuwen

D. Fauconnier

The scientific discipline of “Tribology” refers to the study and science of friction, wear and lubrication between contacting surfaces in relative motion to each other. Although the term “Tribology” has been introduced barely half a century ago by Peter Jost (1921-2016, UK), the art of controlling these processes presumably dates back about 12000 years ago, when people during the Neolithic era (new Stone Age) harnessed frictional heating to make fire using wooden hand- and bow drills.

Archaeological findings demonstrate that already in early times, measures were taken to intentionally influence friction and wear in a way that benefited human beings. After all, necessity is the mother of invention. Although circumstantial evidence found in Mesopotamia (modern-day Iraq) supports the hypothesis that the usage of e.g. lubricants to reduce friction, heating and wear, must have dated back as far as the early Bronze Age, about 3 to 4 millennia B.C., the earliest direct evidence of lubrication was found with the discovery of an ancient Egyptian war chariot from about 1400 B.C., along with traces of a tallow-like lubricant on the axle. However, it was not until the first century A.D. that Plinius The Elder (24 - 79, Rome) published the first written record on the use of lubricants in his work *De Naturalis Historia*.

Over the course of history, many scientists in Europe and beyond, attempted to unravel the fundamentals of tribology, revealing step by step the high complexity of this interdisciplinary scientific field, combining physics, chemistry, mathematics, materials science and engineering, and therefore connects fundamental and applied sciences. Although the names of famous contributing scientists, such as Leonardo da Vinci (1452-1519, Italy), Guillaume Amontons (1663-1705, France), Charles-Augustin de Coulomb (1736-1806, France), Nikolaï Pavlovich Petrov (1836-1920, Russia) and Osborne Reynolds (1842 – 1912, UK) are inscribed into the collective memory of many tribologists and mechanical engineers, also many lesser-known – or perhaps forgotten – researchers have made meaningful contributions to local knowledge building on tribology and its applications.

It is precisely in this perspective that Harry Van Leeuwen will put the spotlight on historical tribological milestones achieved in the Low Countries, during today's academic Sarton lecture.

Harry van Leeuwen was born in 1950 in Vlaardingen, The Netherlands. He obtained his B.Sc. (1972) and M.Sc. degrees (1974) in Mechanical Engineering at Twente University, Enschede. After his graduation, Harry remained affiliated for 2 years to Twente University performing research on dynamically loaded bearings and seals. During that period, he spent half a year at Cornell University (Ithaca, New-York) and at the University of Louisville (Louisville, Kentucky). In 1977 he joined the "*Applied Research Department*" of DAF Trucks in Eindhoven, working on truck fuel economy. In 1979, Harry returned to academia, more specifically as lecturer at Eindhoven University of Technology, where he taught tribological courses to different generations and reconnected with his passion "*fluid film lubrication*". During 1980s, he expanded his field of interest of lubrication in hard contacts in e.g. bearings to lubrication in soft contacts such as radial lip seals. During the late 90's until 2005, Harry mainly involved in teaching activities on general mechanical engineering and tribology, as well as topics related to the engineering profession, ethics and the society. From 2005 to 2009, Harry took a sabbatical leave, and worked as Marie-Curie Research Fellow at "*Shell Global Solutions*" in Hamburg, Germany, which he recently referred to as a most refreshing and interesting period during his career. Returning to TU-Eindhoven in 2009, he re-engaged teaching on Engineering Design, Fuels and Lubricants while coaching new generations of students. From 2018 onwards, he is involved as teacher coach in the Bachelor College of Eindhoven University of Technology and performs research on Elastohydrodynamic lubrication (EHL) and lubricants.

Harry van Leeuwen is a member of Society of Automotive Engineers (SAE), American Society of Mechanical Engineers (ASME), Gesellschaft für Tribologie (GfT) and the Dutch "*Bond voor Materialenkennis – Sectie Tribologie*", of which he is the secretary since 2015.

Because no man can be described solely on the basis of his curriculum vitae, this laudation also deserves attention for the person behind the tribologist.

It was only in a relatively recent past, that my colleague Patrick De Baets introduced me to his "*Dutch colleague*" and long-time friend Harry Van Leeuwen. Despite the relatively short period in which I had the honour to get to know Harry Van Leeuwen, I've learned that Harry is a very sociable and spontaneous person with a broad cultural interest and an outspoken passion for ecclesiastical heritage such as church buildings, organs and liturgical music. As we will witness at the end of this evening, the passion for organs and organ music is shared with his brother Jaco Van Leeuwen. Furthermore, I have been told that Harry's studious and curious nature, his genuine interest in context and stories behind tribological problems, has led him to indulge into research on the history of tribology, specifically in the Low Countries.

It is therefore my pleasure to give the floor to Harry Van Leeuwen for his Sarton-lecture on *"Historical Milestones in Tribology in the Low Countries"*.

Milestones of Tribology in the Low Countries

Harry van Leeuwen

1. Introduction

The formal definition of tribology is that it is “the science and technology of interacting surfaces in relative motion and of the practices related thereto” (Jost, 1966). It is dealing with what the relative motion causes, wear and friction, and to counteract that, lubrication, or lubricants. It has to do with tooth brushing, the movement of human joints, oil as a lubricant for an engine, skating, and the lubrication of bearings, gears, etc.

A written account of how the discipline of tribology has developed over time for the Low Countries at the North Sea has never been written. At first sight this is strange, because technology and science have played an important role since the Golden Age (1590-1700) and the Netherlands, as a small country, has always had a strong international orientation. The inhabitants are familiar with foreign languages, especially the languages of their neighbours, such as French, German, and English. Therefore, they have always been well informed about developments in other countries.

In the global history of tribology, larger countries such as Great Britain, Germany, the USA, Russia and France play an important role. Dowson (1979), in his *History of Tribology*, shows that tribology developed from Ancient Times through the Middle Ages, the Renaissance and the Industrial Revolution to a multi-faceted discipline in modern times. In recent decades, India and especially China have joined the field.

The role of the Low Countries in this development is quite modest. But the Low Countries were demonstrably present and influential since the intervening period preceding the industrial revolution.. This essay is about the contribution to the development of tribology in three directions:

- a short history of the Tribology Section in the Material Science Association (BVM), section 2
- the tribological institutes in industry and at universities in the 20th and 21st centuries, section 3, and
- an overview of the most important tribologists in the Low Countries, the "Men of Tribology", section 4

2. The tribology Section in the Material Science Association (BVM)

At the beginning of the twentieth century, there was an "International Federation for the Knowledge of Building Materials" in the Netherlands, which regularly organised conferences on building materials in general. During the First World War, interest disappeared and only revived some time afterwards. f M.E.H. Tjaden, Director of the Construction and Housing Authority in Amsterdam, and prof. J.A. van der Kloes, Professor of Building Materials at the TH Delft, conceived the new foundation. At a meeting on 19 March 1926 in the American Hotel in Amsterdam, the Association was established. The field of interest was extended to include materials commonly used, for example, in mechanical engineering, shipbuilding and aeronautical engineering. As a result, the "Federation for the Knowledge of Building Materials" was renamed "Bond" (Association, or Union). At the first meeting of the "Bond" on 23 June 1926 at the Industrial Club in Amsterdam, the name "Material Science Association" (BVM) was adopted. The first chairman was prof. J.A. van der Kloes, followed by M.E.H. Tjaden.

The task of the BVM was described as "study of the materials of technology in the broadest sense". As early as 1927, an international congress was organised in Amsterdam in collaboration with the Swiss Materials Testing Office (N.N., 2015).

Among the persons who have held the office of BVM chairman, metal scientists prof.dr.ir. W.F. Brandsma (1939-1942), prof.ir. P. Jongenburger (1971-1984) and prof.dr.ir. S. van der Zwaag (2000-2007) received international acclaim. Among these presidents there also is a tribologist: prof.ir. R. Bosma from the Tribology Group of UT Twente (1984, see also sections 3.4 and 3.10).

At that time there was no central institute for materials research in the Low Countries. The Materials Science Association campaigned for such an institute from the beginning. In 1929, the "Foundation for Materials Research" was established, from which the TNO (Netherlands Organisation for Applied Scientific Research, see section 3.6) arose in 1932. Because of the great variety of topics, the federation was organised in "kringen" (rings, groups). The first to be established was the "Building Materials Kring". This was followed by the "Metals Kring" and in 1933 by the "Kring for Paints, Rubber, Bitumen and Other Plastics".

On the occasion of a meeting on lubrication of the"Kring Metal" on 26 February 1942, the board of the association decided to establish a "Kring for Lubricants and Lubrication". The first chairman was, most probably, ir. B.H. Moerbeek, who worked at the Shell Laboratory in Amsterdam and was a colleague of Harmen Blok in the 1940s. Blok briefly was chairman in 1950, then Moerbeek again. On 1 January 1955, Dr P. Meerburg became Chairman of the Lubricants and Lubrication Kring.

Prof.ir. H. Blok, by now a professor at the University of Delft (THD), advocated paying more attention to wear in 1952, whereupon a "Wear Kring" was founded. Blok became its first chairman on 1 January 1954. The two groups, "Lubricants and Lubrication" and "Wear", existed side by side for a considerable time. Because of the similarities between the topics, there were usually joint meetings, which were then recorded as the activity of the "Lubrication and Wear Kringen". The notes of the secretary of the BVM show that this name was already used in 1961. However, it is not clear whether there was already an official merger of the "Kringen" at that time. The names of these groups continued to exist until 28 September 1971. From then on, only the name "Kring Tribologie" was used. From 1990 onwards, the name "Tribology Section" appeared and has remained so until today.

Today, the Materials Science Association is a network of experts in the field of materials technology. The current 800 or so members are mainly researchers and technical staff at universities, research institutions and industry. The Tribology Section has about 75 members. Its mission is "... the promotion and exchange of knowledge in the field of 'running surfaces' with the main objective of optimising the service life and performance of machines and equipment. Emphasis is placed on materials, material selection, coatings, heat treatment, lubrication, friction, wear, heat generation and dissipation, energy consumption, load capacity, maintenance, clearance, bearing selection, sheet metal forming, machining, stick-slip, noise, accurate positioning, etc.” (N.N. 2015, p. 41).

The members of the section’s board from the very beginning cannot be traced. Some chairmen can be found, with some uncertainty, in the BVM archives:

- ing. B.H. Moerbeek (Shell, 1942-1950) [1]
- prof.ir. H. Blok (Shell/THD, 1950-1952) [1]
- ing. B.H. Moerbeek (Shell, 1952-1955) [1]
- prof.ir. H. Blok (THD, 1954-1955) [2]
- dr. P. Meerburg (Shell, 1955-1958) [1]
- prof.ir. R. Bosma (University Twente (UT), 1976-1982 or later)
- dr.ir. G.J.J. van Heijningen (THD, ? - 1996)
- ir. W.E. ten Napel (UT, 1996-2000)
- dr.ir. A. van Beek (THD, 2000-ca. 2008)
- prof.dr.ir. D.J. Schipper (UT, ca. 2008-2015)
- prof.dr.ir. P. De Baets (UGhent, 2015-present)

Since 2015, H.J. van Leeuwen (TU/e) has served as secretary, succeeding dr.ir. M.B. de Rooij.

3. Institutes in the Low Countries

By the end of the 19th century friction problems occurring in industries like mining, railways and weaponry, induced many tribological investigations. The first written accounts of friction in bearings are from Petrov (1862), Tower (1883), and Stribeck (1902), reviewed by Dowson (1979), and Martens (1888) . These industries were presented stronger in southern Belgium than in other parts of the low countries. The oldest documented activities stem from Hanocq (1925) from Liège.

Several institutes and laboratories, from industry as well as universities, have played a decisive and international role in the development of tribology. The following is a brief chronological overview, ordered by its starting date.

1 This was a forerunner of the Tribology Section, the Kring for Lubricants and Lubrication, from 1942.
2 This was a forerunner of the Tribology Section, the Kring for Wear, from 1954.

3.1. University of Liège (1927 - today)

The first tribological activities at Liège University can be dated around 1927, thereby being the oldest and first institute in this chronological list of institutes.

- **Laboratory for Machine Elements in the Department of Mechanical Engineering (1927 - 2021)**

  C. (Charles) Hanocq (1881-1961) succeeded Henri Deschamps in 1919 as the chair holder of machine design, especially on machine elements, rotating equipment (turbines and pumps) and internal combustion engines. He became a full professor in 1923 and built the new Laboratory for Machine Elements, which he described in (Hanocq, 1925). Two years later a friction test rig was completed, and measurements were reported (Hanocq, 1927). Hanocq retired in 1950, and was succeeded by his laboratory manager, L. (Lucien) Leloup (1907-1976). Leloup had been Hanocq's assistant since 1931 and became a lecturer in 1950 and full professor of the chair in 1954. He investigated journal bearing friction behaviour around the transition point, where friction is at a minimum, and came with a critical parameter to define its transition. At Liège University is was called the *Leloup critical parameter*.

  In his last years professor Leloup was a university board member. After his death in 1976 he was succeeded by J. (Jean) Bozet, who taught, and investigated in, tribology from 1975 until his retirement in about 2003. Around 2003 J.-L. (Jean-Luc) Bozet, not related to the previous one, investigated tribology space applications in this laboratory.

- **Cryotribology Laboratory in the Department of Chemical Engineering (2022 - present)**

  In 2022 the tribology group within Liège university moved from Mechanical to Chemical Engineering, with J.-L. Bozet as the full professor, into a new lab, called Beblue. The lab facilities are very special and all about low temperatures. Machine elements studied are ball and hydrostatic bearings, seals, valves, etc., for space applications.

3.2. Shell (1928 - today)

- ### The Delft Laboratory (1928 - 1975)

The Delft Experimental Station of N.V. De Bataafsche Petroleum Maatschappij, or the "Delft Laboratory" for short, was founded in 1928 as a fuels development laboratory and also to be less dependent on third-party research, such as Ricardo. Initially it was an engine laboratory. Within a few years, lubricants were also tested there. The first director was G.H. (Gerrit) Boerlage, the inventor of the four-ball apparatus (see Boerlage, 1933, and Figure 3.1). From 1933-1951 Harmen Blok worked here (more in sections 3.4 and 4.4). From the late 1960s onwards, more and more of the lubricant development was transferred to the Koninklijke/Shell-Laboratorium Amsterdam (KSLA). This led to the closure of the Delft laboratory in 1975.

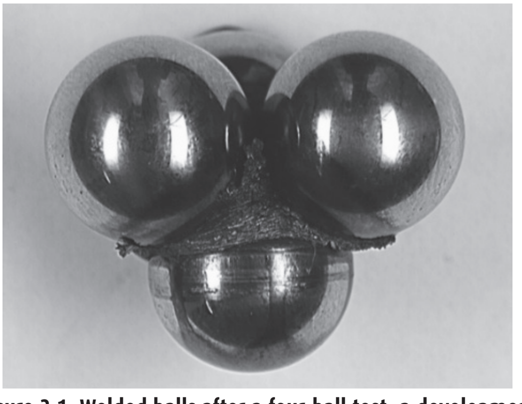


Figure 3.1: Welded balls after a four-ball test, a development from the 1930s at Shell's Delft laboratory.

- ### The Royal Shell Laboratory Amsterdam KSLA (1975-2007)

At the end of the 1960s, the KSLA was given its own large hall for the huge ship engines of the time. Lubricants for shipping were also tested there. Much of the development of engine oils was housed at the new Thornton Research Centre near Chester, UK, around 1949. As in Germany, the automotive industry in England was much stronger than in the Netherlands. Shell felt that it would be better for the R&D groups to be located near the motor manufacturers. A smaller part of this, namely motor oils for passenger cars, was also developed in Amsterdam for a while.

- ## The Royal Dutch/Shell Thornton Research Centre TRC (1947-2013)

Shell had an operational Aero Engine Laboratory in Chester, UK, since 1941. Between 1941 and 1945, two further laboratories were built to research chemicals derived from petroleum. Also in 1945, a laboratory for diesel fuels was commissioned. These four laboratories were merged on 1 February 1947 to form the Thornton Research Centre (TRC). The TRC grew into a large laboratory and in the 1960s-1990s housed a world-renowned tribology group that provided much of the basic research on lubricated and non-lubricated contacts. After graduating in 1957, Roel Bosma was one of the first Dutch engineers to work here (see also sections 3.4 and 3.10).

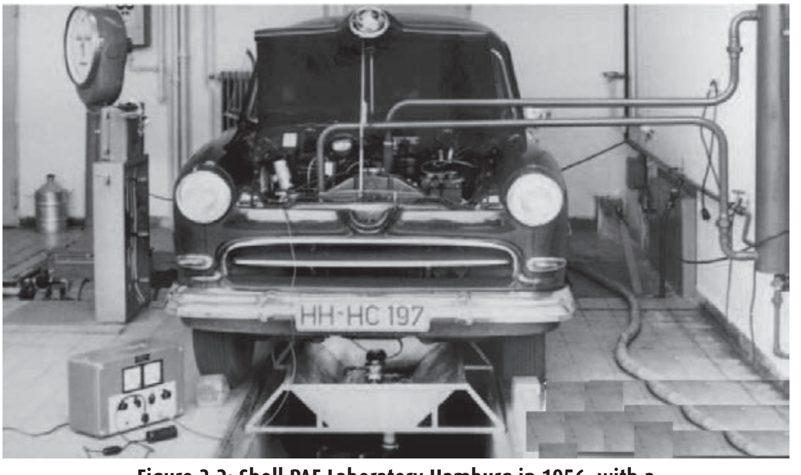


Figure 3.2: Shell PAE Laboratory Hamburg in 1956, with a Ford Taunus on the first roller dynamometer.

- ## The Shell PAE Laboratory, now STCHA, in Hamburg (1956 - present)

Additionally should be mentioned the German Shell PAE Laboratory, because many Dutch people worked here. Since 1956 Shell has had a development laboratory in Hamburg, the Products Application and Development Laboratory (PAE, Figure 3.2). Initially it was only a service laboratory for the German market, but gradually it became a development laboratory for the entire Shell Group. Around 2004, the development of oils for marine engines was transferred from KSLA to the PAE laboratory. Many Dutch people worked at the Marine Power Innovation Centre (MPIC) in Hamburg, especially during the transfer from Amsterdam to Hamburg.

- **Shell University UTC's (2013-present)**

  Much of Shell's fundamental research is now organised in University Technology Centres (UTC's). At Imperial College, London, Shell established a UTC for fuels and lubricants in 2013. Tribology activities are housed in Daniele Dini's Tribology Group, one of the largest tribology research groups in the UK.

3.3. Lubricants Association Belgium (LAB, 1934-present).

LAB was founded in 1934 to represent the professional interests of its Belgian members, in the manufacture, marketing and/or processing of lubricants and products derived of them. Activities are

- the organisation of the annual BeNeLux Lubricating Oil Conference, together with the Dutch VSN (see under section 3.5), and the Tribology Section in the BVM;
- co-founder of Valorlub, the Belgian institute for management of used oil, to introduce the Belgian mandatory take-back of used oil;
- advocacy activities

LAB is a member of the Union of the European Lubricants Industry, UEIL, the European trade association.

3.4. TH Delft (1951 - present)

- **TH Delft, Laboratory for Machine Elements and Tribology (1951 - 2004)**

  With the appointment of Harmen Blok to the Department of Mechanical Engineering at Delft University of Technology in 1951, the Laboratory for Machine Elements, later renamed the Laboratory for Machine Elements and Tribotechnology (WO & TT), was started, see Figure 3.3. The small group became known primarily through the work of Blok, who attended many international conferences, wrote many papers, and acted as a consultant to many industries.

  Prof.ir. H. Blok trained almost 100 engineers. He was a very demanding supervisor and the length of his engineer's program was a long one in

Mechanical Engineering at the TH Delft [3]. Some of these engineers and Ph.D. students trained by him achieved international fame: R. Bosma (1957), G.G. Hirs (1960), F.H. Theyse (1960), O.J. Koets (1962), K. Herrebrugh (1963), D. Landheer (1963), H.J. Koens (1964), H. Moes (1964), G.J.J. van Heijningen (1972) and C.J. Thijsse (1978).

The best known doctoral students, having Blok as their first supervisor, are:

- E.A. Muijderman (1964, cum laude, on spiral groove bearings, see section 4.5).
- C.J.A. Roelands (1966, cum laude, on a viscosity relationship, see section 4.10)
- G.G. Hirs (1970, a bulk flow theory for turbulent lubricating films in grooved bearings)
- G.J.J. van Heijningen (1981, gear cooling by lubricant spinning off, see section 4.8)
- A.R. Savkoor (1987, dry adhesive friction of elastomers)

Blok retired in 1981. Gerard van Heijningen, who by then was working as a scientist in the laboratory, ensured the continuity of the WO&TT group. Blok was eventually succeeded by Ton de Gee in 1985, see also 4.7. Besides being a manager at TNO, he became part-time professor in tribology.

3 Besides Machine Elements and Tribotechnology, Fluid Mechanics and Mechanics had a course that lasted a year longer than all others in Mechanical Engineering.

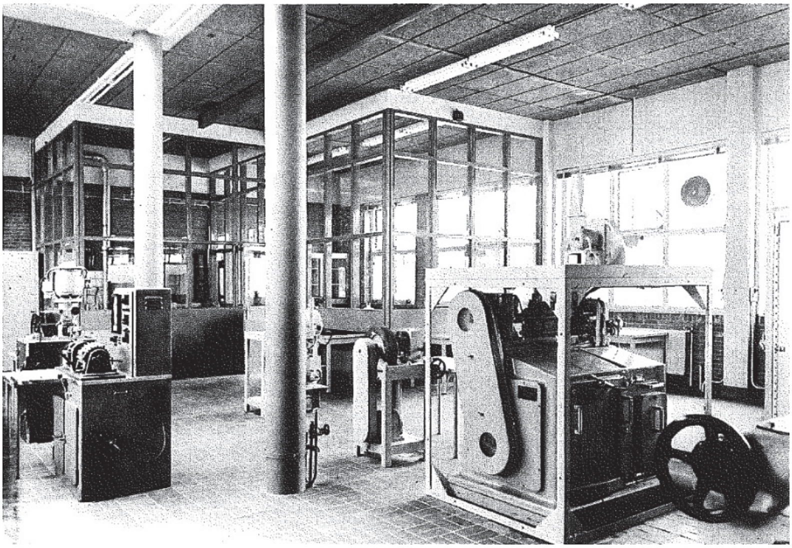


Figure 3.3: Laboratory for Machine Elements at the TH Delft (foreground right: a gear testing device, 1959).

The group continued to be of modest size. A. (Anton) van Beek joined the staff in 1990 and R.A.J. (Ron) van Ostayen joined the permanent staff in 1991, after serving on a temporary basis since 1989. The group was discontinued in 2004. The end of an "empire".

- **TH Delft, Laboratory of Automotive Engineering, Tyre Research (1954 - 1996)**

In 1950 Delft University appointed prof.ir. H.C.A. (Herman) van Eldik Thieme (1915-2004) as the new professor in Vehicle Research within the Mechanical Engineering Department. He started a provisory Laboratory for Vehicle Research in 1954, which moved into a new building in 1958 (see Van Eldik Thieme, 1959).

Under his guidance and that of dr.ir. A.D. (Ton) de Pater, Ph.D. student H.B (Hans) Pacejka (1934-2017) studied the wheel shimmy phenomenon. He has held the position of full professor in Vehicle Research from 1980 until 1996. Hans focussed on tyre-road contacts and he, his group, and many others around the world, worked on an empirical formula to assess the friction between tyre and road, called the *Magic Formula*, and still finds much acclaim, see Pacejka (1996). Figure 3.4 yields an impression of the Delft Test Tyre Trailer, which was developed in cooperation with the TNO Road Vehicles Research

Institute. It can handle both personal car as well as motorbike tyres on real road surfaces, wetted and dry. The lab was closed by the end of the 90s and the more recent test rigs were moved to the Vehicle Laboratory of TU/e.

Figure 3.4: Delft Test tyre Vehicle (N.N., 1995).

- **TH Delft, Laboratory for Contact Mechanics in Engineering Mechanics (1960 - 2002)**

The appointment of A.D. (Ton) de Pater (1920-2001) as an Engineering Mechanics Professor at TH Delft in 1958 led to interest into rail contact mechanics, and to a lab which also covered wheel-rail contacts. From 1960 onwards J.J. (Joost) Kalker worked in this lab on rolling contact friction and became the world leading expert in this field. The laboratory in Delft ceased to exist by the end of the 1990s. Joost retired in 2002. See also under section 4.6.

- **TH Delft, Railway Engineering in Civil Engineering (2012-present)**

Since 2012 R.P.B.J. (Rolf) Dollevoet (*1970) has a position in the Faculty of Civic Engineering as a parttime professor with a chair in Railway Engineering, next to his work with Dutch ProRail as a railway system expert. He studies rail and wheel geometries to reduce wear, which leads to improved rail profiling. Dollevoet uses the Kalker codes and by doing so, he continues Delft's tradition in the field.

3.5. Association for Lubricant Companies in the Netherlands (VSN, 1952-present).

The Association for Lubricant Companies in the Netherlands VSN in The Hague was founded on 27 June 1952 to unite the interests of manufacturers, importers and exporters of lubricants. Its members include large, medium and small companies. J. (Jos) Jong is the chairman of the board. The main activities of VSN are:

- the publication of a trade journal, “De Smeeroliekroniek” (“Lubricating Oil Chronicle”)
- the organisation of the annual BeNeLux Lubricating Oil Congress together with the Belgian sister organisation LAB (see under section 3.3)
- the organisation of a tribology course

VSN is a member of the Union of the European Lubricants Industry, UEIL, the European industry association.

3.6. TNO Tribology Group Apeldoorn, later Eindhoven (1955 - 2010)

The Dutch “organisatie voor toegepast natuurwetenschappelijk onderzoek” (Netherlands organisation foor applied scientific research or TNO) was charted in 1932 by law to make existing knowledge applicable to companies and the government. As a public organisation, TNO has an independent position. In the mid-1950s, the then TNO board under chairman prof. D. Dresden realised that friction and wear could be an interesting research topic on which to spend public money. Dresden consulted prof. H. Blok and Dr. G. Salomon (section 4.3) about an exploratory study on the possibilities of friction and wear research. The result led in 1955 to the foundation of a department for friction and wear under the direction of ir. J. Beekhuis. The section was placed under the supervision of the physics department of drs. J.H. Zaat, later professor at TU (Technical University) Eindhoven and successor of prof.dr.ir. W.F. Brandsma (chairman BVM from 1939-1942, see chapter 2).

Under A.W.J. (Ton) de Gee, a young chemical engineer who started at TNO in the late 1950s, friction and wear research gained an international reputation. De Gee became head of the new Surface Treatment and Tribology (OBT) group at the TNO Metaalinstituut (Metal Institute), see Figure 3.5.

De Gee collaborated a lot with ir. D. (Dick) Landheer from TU Eindhoven (see under 3.9). This collaboration led not only to many coordinated experiments, but also to a course manuscript that was used at all three Dutch Technical Universities in the 1990s (Landheer and De Gee, 1993). See also under section 4.7.

Figure 3.5: The TNO Friction and Wear Laboratory in Delft, shortly before the move to Apeldoorn, ca. 1971.

Initially, there was a strong focus on investigating the relationship between the chemical composition and structure of the alloys on their friction and wear behaviour. Among other things, it was clearly identified that adhesion between contact surface materials also plays an important role in technical systems. Later, there was more emphasis on the development of practical test methods based on a "systems approach ". Close cooperation with Geert Salomon (TNO, more in section 4.3) and Horst Czichos from the Federal Institute for Materials Testing (BAM) in Berlin were instrumental in this respect. Many experiments were run on the TNO pin on disk test rig (Figure 3.6), which was a success and in use in several other institutes like Delft and Ghent.

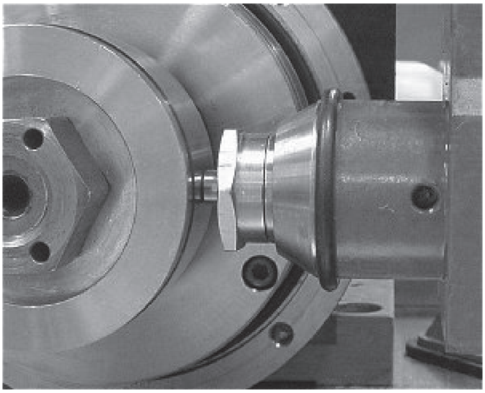


Figure 3.6: The TNO Pin on Disk wear test rig[4]

Even before Zaat left for Eindhoven, the *International Research Group on Wear of Materials* IRG/OECD was founded, with Dr. R.L. (Bob) Johnson from NASA as the first president and Zaat as the first technical secretary. Initially, the group led a rather unremarkable existence. When, at Johnson's suggestion, under secretary De Gee, the study of marginally lubricated systems began, successes were achieved. This eventually led to the formation of the IRG transition diagram, see Figure 3.7. This has become internationally known through the many publications devoted to it, see De Gee et.al. 1985.

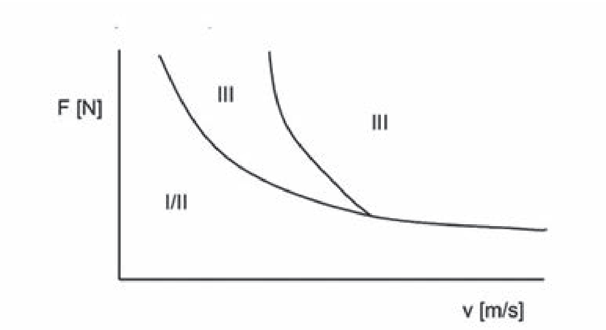


Figure 3.7: The generic IRG-OECD (International Research Group on Wear of Materials/Organisation for Economic Cooperation and Development) transition diagram (De Gee et.al., 1985).

In the 1990s, the TNO management decided to gradually move the Metaalinstituut to the TU/e campus in Eindhoven. The group was now called the Tribology Group and was part of one of many TNO institutes, TNO

[4] Better were to designate this geometry as "pin on ring".

Industry. In 1998, 12 tribologists worked there under the leadership of dr.ir. A.J. (Bert) Huis in ‘t Veld. The orders came from industry and the project leaders had the important task of securing enough orders.

In the course of the decade, the decision was taken to discontinue all activities in the tribology field.

3.7. Philips Eindhoven (1960 - 2000)

- **Philips NatLab - Physics Laboratory, Tribology and Fluid Mechanics Group (1960-1990)**

When Evert Muijderman started at NatLab in 1956 (see also section 4.5), he chose a tribological topic: an axial sliding bearing, applied in an audio turntable. This can be seen as the first serious and structural involvement with tribology within Philips. There was an atmosphere of free research in NatLab at the time, with plenty of time and budget to investigate all kinds of questions thoroughly.

Figure 3.8: The Muijderman group at Philips NatLab, Waalre/Eindhoven, in 1972.

Muijderman knows how to promote the importance of tribology for Philips. From 1963 he is in charge to lead a group dedicated to tribology and fluid mechanics. It is known as ‘Group Muijderman’, see Figure 3.8.

In 1972, the group grew to about 20 people, almost half of whom work on tribological topics. Muijderman gained world fame with his long-term efforts to lay the foundation for the theory of the spiral groove bearing (SGB) to be developed into a manufacturable product for many applications. The bearing type was extremely successful in extending the life of Röntgen tubes (see Figure 3.9), and in increasing the density of hard disks (Moore's law) [5].

Besides these SGB's, the group worked on air bearings (P. Holster and J. Jacobs), hydrostatic bearings (H. Kraakman and J. de Gast), foil bearings (P. Rongen), rubber seals (for the Philips Stirling engine), mixed lubricated running contacts, precision grinding (J. Franse), EEM calculations on lubricated and non-lubricated contacts (A. Leeuwestein, T. Tangena, F. Baaijens) and dry running systems.

The Muijderman Group was a breeding ground for scientific talent. Several group members later became professors and Baaijens was appointed Rector Magnificus of TU Eindhoven in 2015.

When Muijderman left Philips in 1988, ir. B. Sastra became head of the group. The focus quickly shifted and tribology became irrelevant within a few years.

- **Philips Centre for Manufacturing Technology CFT - Tribology Group (1975-2000)**

The Philips Centre for Manufacturing Technology (CFT) was founded in 1968 to develop new technologies for the parent company. By 1999 it employed almost 1,000 people. In the late 1990s, the name CFT was changed to Philips Applied Technologies. In 2012, CFT became part of Philips Innovation Services (PINS) and the old name disappeared.

CFT is much closer to Philips' product groups. The research is therefore much more practical than in NatLab. The beginning of a tribology group within the CFT is around 1975, and when Philips decided to focus more on medical applications in the 1990s, biotribology issues became important. At CFT, almost all years were dedicated to unlubricated and poorly lubricated tribosystems (F. Bremer, J. van Kuilenburg). In addition, after their disappearance at NatLab, some subject areas remained supported by the

[5] This was mainly due to its very good predictability of the disk position.

CFT for many years, such as air bearings (T. Ruijl, J. Post), hydrodynamic and hydrostatic bearings (D. Bemelmans, B. de Veer) and boundary-lubricated contacts (R. Severt). PINS continues to be the home of the semiconductor and air bearing activities.

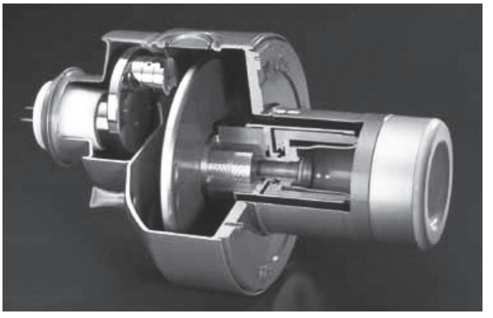


Figure 3.9: The Philips Maximus Rotalix Ceramic X-ray tube (MRC, 1989).

3.8. SKF Engineering and Research Centre ERC, Nieuwegein (1972 - present)

Svenska Kullager Fabriken (SKF) already had an R&D laboratory in the USA (King of Prussia, 1963), as well as research activities in the plants in Sweden (Gothenburg, 1912) and Germany (Schweinfurt, 1929), when the decision was taken in the late 1960s to establish a research centre in Nieuwegein in the Netherlands: the SKF European Research Centre, ERC. This was opened in 1972 and from the beginning had a group that conducted tribology research. Gradually, the global research activities were pooled in the ERC, which was henceforth called the SKF Engineering and Research Centre ERC. In 2014, SKF decided to establish a Global Technical Centre Europe, consisting of two locations: the existing ERC and a second facility in Gothenburg. SKF's other Global Technical Centres are located in India (Bengaluru) and China (Shanghai).

Many of the life cycle tests for the SKF Group are carried out at the ERC. One of the first heads of the Tribology and Life Cycle Testing Department was ir. P.K. (Paul) Leenders (manager in 1978-1985). From the beginning, the ERC has made important contributions in the field of lubrication and life of rolling bearings. Important for the progress of tribology, here were R.S. Heemskerk, T.A. Harris (executive director 1980-1985, known for his books on rolling bearings), J.H. Tripp, E. Ioannides, G.E. Morales-Espejel, and P.M. Lugt (grease lubrication of rolling bearings, see Lugt 2013).

3.9. TU Eindhoven, Power Transmissions and Tribotechnology Group (A&T (Aandrijf-en Tribotechniek), 1958-2001)

Tribological activities at TU Eindhoven (TU/e) are very fragmented. Tribology was also present in the Departments of Chemical Engineering and Applied Physics, but most of the research was carried out in the Department of Mechanical Engineering, and it had a more continuous base. Within Mechanical Engineering, tribology was mainly studied in three groups:

- **Small Mechanical Systems (1958-1974) and Power Transmissions and Tribotechnology Group (1976-2001)**

  Prof. A. (Alexandre) Horowitz (1904-1982), a highly creative mind and inventor of the Philishave rotary shaver, was appointed professor in 1958. Since the 1970's and under his leadership, staff member ir. M.H. (Mat) Cuypers worked on continuously variable transmissions (CVT's), and crown gears, leading to many patents. Horowitz retired in 1974.

  His successor, prof.dr.ir. M.J.W. (Jeu) Schouten (*1945), consolidated and centralised the role of tribology at TU/e. He managed the Power Transmissions and Tribotechnology Group (A&T) from 1976 until he became Dean of the Faculty of Industrial Design in 2001. When he stepped down from the faculty of Mechanical Engineering, the term Tribology disappeared in the name of a group at TU/e.

  Jeu Schouten obtained his doctorate in 1973 under the supervision of hydraulics professor prof.dr.ir. W.J.M. (Joep) Schlösser (1927-2021) on a dissertation sponsored by the *Verband Deutscher Maschinen- und Anlagenbau* (VDMA), a consortium for German mechanical engineering industrial members. What was special and typical for the time was that Schouten published his dissertation in German (Schouten, 1973). The focus was on the further development of thin-film signal transducers for film thickness, pressure and temperature determination. Schouten provided convincing experimental evidence that the so-called Petrusevitch peak ("spike") in the EHL contact is not a theoretical product but really exists, see Figure 3.10. His study received much attention, especially within Germany. At many universities, these sensors were used in various research projects.

In 1979 ir. H.J. (Harry) van Leeuwen (*1950) joined this group. Initially, he was engaged in EHL (elastohydrodynamic lubrication) of lubricated metal contacts. In the course of time he studied flexible (soft) contact lubrication, as with lubricated seals, and again with stiff (so-called hard) lubricated contacts, in the quest for better approximative film thickness formulas (van Leeuwen, 2009).

- **Materials Science Group (1962-1994)**

Prof. drs. J.H. (Johan) Zaat (1920-1994) came to the TU/e from TNO in 1962 to manage the Materials Science Group as a full-time professor.

With the appointment of ir. D. (Dick) Landheer (*1938) in 1964, a small group started in the field of wear research. This group has been working in intensive collaboration with TNO (De Gee) and BAM Berlin (Czichos). The collaboration with De Gee led to the IR/OECD transition diagram and a joint course manuscript (Landheer and De Gee, 1993). After Zaat's retirement in 1990, the Materials Wear Group was integrated into the A&T Division. Landheer retired in 2003. By then the A&T Division no longer existed.

Dr. dipl.-ing. J.H. (Hans) Dautzenberg (*1938) came to the Zaat chair in 1965 and studied the fundamentals of wear and friction in dry sliding contacts, which was based on plasticity mechanics principles. In the late 1980s he moved to the Division of Manufacturing Technology and Automation and worked on machin properties of materials under prof. Dipl.-ing. J.A.G. (Jo) Kals (1934-2010), later prof.dr.ir. F.P.T. (Frank) Baaijens (*1958), until about 2002, his early retirement.

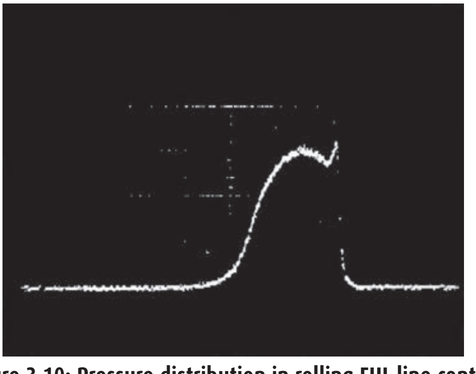


Figure 3.10: Pressure distribution in rolling EHL line contact for 1 GPa, 0.025 m/s (Schouten 1973, p. 347).

- **Engineering Mechanics/Polymer Technology Group**

  Since prof.dr.ir. J.D. (Jan) Janssen (*1940) took over the Division of Technical Mechanics from prof.ir. W.L. (Wim) Esmeijer (1919-2003) in 1971, work has been done here intermittently on contact problems. Research was usually carried out in collaboration with companies such as Philips NatLab (see 3.7). When Jan Janssen was appointed to become the new Dean in the Faculty of Biomedical Engineering, around the year 2000, this work moved to the Polymer Technology Group of prof.dr.ir. H.E.H. (Han) Meijer (*1949). Tribology studies became more experimental. After Meijer's retirement in 2014, tribological research continues under the leadership of his successor, Prof. P.D. (Patrick) Anderson (*1968), with a more incidental character.

3.10. University of Twente, Lubrication and Wear Group, since 1971 Tribology Group, since 2002 Tribology and Surface Technology Group (1965 - present)

In 1965, prof. R. Bosma (1931-2017) was appointed as a lecturer at the then Technical University of Twente (UT). Until then he was a researcher at the Royal/Shell Thornton Research Centre in the UK (section 3.2). His task was to teach, and perform research in, lubrication and wear, initially in the Materials Group of prof. Verbraak (deceased 1983). In 1969 the group became independent and was named "Lubrication and Wear". Around 1971 the name was changed to "Tribology Group" and in 1972 Bosma received an appointment as full professor.

Roel Bosma was a very motivating teacher and a good team builder who gathered very good scientists in his group. Under his leadership, mechanical engineers ir. H. (Hans) Moes (*1936) and ir. W.E. (Wijtze) ten Napel (*1940) carried out research into (elasto-) hydrodynamic lubrication and friction. Wear problems were studied from 1971 by the physicist ir. P.H. (Peter) Vroegop, who worked in the group until 1987. When Roel Bosma retired in 1988, he left behind a thriving group. It is mainly thanks to the efforts of Wijtze ten Napel in the intervening years that the group still exists. Thanks to his great commitment, a part-time position for a professor became possible, and this became prof.ir. A.W.J. (Ton) de Gee in 1996.

In retrospect, it can be said that with Hans Moes' move from Delft to Enschede in 1967, the tribological focus of the Netherlands shifted from Delft to Twente. Moes' influence on graduates and Ph.D. students is very significant. He passed on much of what Blok saw as the 'Delft School' to his own students and wrote some very highly valued papers. These are to a large extent included in his tribological legacy, in *Lubrication and Beyond* (Moes, 2000). Moes retired at the beginning of 1997. His approximation formulas for the central and the minimum layer thickness in EHL line contact (Moes, 1965) and EHL elliptical contact (Moes, 2000) are famous. See also section 4.9.

Figure 3.11: Laboratory of Tribology and Surface Engineering at UT (picture taken 23 Nov. 2007)

In the 1980s, the seed was sown for later flowering and harvesting. Several tribologists were trained at the University of Twente, who attracted attention with their dissertations and later work:

- A.A. (Ton) Lubrecht in 1987 on the multi-grid method for EHL contact (Lubrecht, 1987). Ton became a full professor at Institut National des Sciences Appliquées (I.N.S.A.) de Lyon in ca. 1995, succeeding Maurice Godet.

- D.J. (Dik) Schipper in 1988 with considerations and further elaboration of the IRG-OECD transition diagram (Schipper 1988). In 2002, UT appointed Schipper as a professor in the tribology group, which from then on was called Surface Engineering and Tribology. Schipper built himself a new laboratory, see Figure 3.11.

- C.H. (Kees) Venner in 1991 on the multi-grid method for EHL contact with rough surfaces, see Figure 3.12 and Venner (1991). Kees Venner is the new professor of Engineering Fluid Dynamics since 2015. Within the broad field of fluid mechanics, his interest in very thin films remains.
- P.M. (Piet) Lugt in 1992 on the multi-grid method in cold rolling of steel and aluminium. From 2012 Piet is a part-time professor in the Surface Technology and Tribology Group, in the field of tribology-based maintenance, next to his role as a manager within SKF/ERC. He currently is a world leading expert in lubricating greases.
- M.B. (Matthijn) de Rooij in 1998 on friction with unlubricated deep drawing processes. He recently took over the role of fulltime professor of the group from Schipper.
- E. (Emile) van der Heide in 2002 on models for friction and wear in lubricated sheet metal forming processes. Since 2009 he has been a part-time professor, since 2019 a full time, in the area of biotribology (skin and joints).

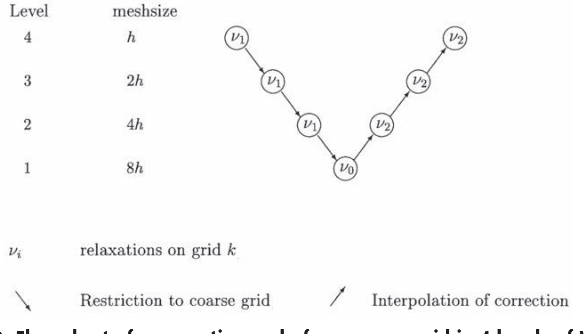


Figure 3.12: Flow chart of a correction cycle for a coarse grid in 4 levels of V-type, by C.H. Venner (source: https://www.researchgate.net/publication/280783983).

3.11. University of Ghent, and Soete Labo (1970 - present)

- **Laboratory of Machines and Machine Construction (LMM) and Soete Laboratory (1971-present)**

  Prof.ir. C. (Carl) Dekoninck (1937-2016) started his academic career with Ghent University in 1971, see section 4.11. Tribology as a subject became important and Dekoninck introduced the discipline in his lectures in Mechanical Engineering. In 1972 prof.dr.ir. M. (Michel) Vermeulen (*1949) became his assistant and started a Ph.D. project on hydrostatic bearings. At that time there were close contacts with the global tribology community through international conferences, among others Erich Pollmann (Ruhr University Bochum), Gerard van Heijningen (TUD, see section 4.8), Roel Bosma (UT, see section 3.10), and Horst Czichos (Bundesanstalt für Materialforschung und -prüfing (BAM) Berlin, see sections 3.6, and 4.7).

Dekoninck's colleague prof.dr.ir. W. (Walter) Soete (1912-2002) was the director of the Laboratory for Resistance of Materials and Welding Engineering, which could handle large objects. Together they designed and built a Large Scale Friction Tester (LSF), see Figure 3.13. The LMM and Soete laboratories merged in the 90's.

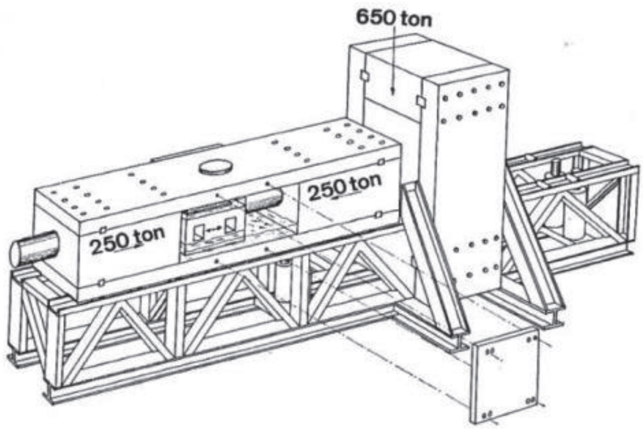


Figure 3.13: The LSF (Large Scale Friction Tester) in the Soete Laboratory

In 1997 dr.ir. P. (Patrick) De Baets (*1966) is appointed as a professor in LMM. After a reorganisation in 2000, De Baets and Dekoninck step down LMM and join Soete Lab. De Baets is a full professor in 2005 and the new director of Soete Lab, dr.ir. D. (Dieter) Fauconnier (*1981) is appointed as professor in 2015.

The main activities are: broader engineering and technology; mechanics of deformable solids; numerical modelling and design; tribology; surface roughness; large scale testing. This last activity is a specialty in Europe. All other tribology laboratories have small-scale test facilities for budgetary reasons.

- **OCAS (1990 - 2009)**

  "Onderzoekscentrum voor de aanwending van staal" OCAS is a research centre of ArcelorMittal R&D for the application of steel, situated in Ghent. In 1990 prof.dr.ir. Michel Vermeulen starts tribology research at OCAS, with a focus on the influence of surface topography on friction in deep drawing processes. He establishes a mechanical workshop and a metrology lab here. In these years he develops a criterion for lubricant breakdown under sliding conditions with steel, having a certain roughness and texture. It is based on Halling's 2D plasticity index and resulted in a modified 3D Plasticity Index for lubricant breakdown (ψ). Vermeulen retires from OCAS in 2009 and that brings an end to the tribology activities there.

3.12. University of Leuven, research and spin-offs (1971-present)

- **Air Bearings (1971 - present)**

It was prof.dr.ir. R. (Raymond) Snoeys (1936-1987), in the division of PMA (Production Engineering, Machine Design and Automation) within the Department of Mechanical Engineering, who started gas bearing research in the early 1970's. Snoeys was particularly interested in advanced production techniques, and this bearing type enabled more precise metal machining. His first Ph.D. student to study air bearings was dr.ir. E.J. (Eric) Blondeel (*1944), who obtained his Ph.D. on aerostatic bearings with a load-dependent gap configuration in 1975. More Ph.D. theses followed. F. (Farid) Al-Bender (*1951) joined this group in 1984 and completed a thesis on aerostatic bearings in 1992.

Many types of bearings were investigated: self-acting, as well as externally pressurized bearings, rigid as well as compliant; porous materials, tilting-pad types, and miniature (ultra-) high-speed bearings, which may operate in the turbulence regime.

In 2006, a spin-off from Leuven University started as LAB Motion Systems (Leuven Air Bearings NV). Currently, dr.ir. K. (Kris) De Moerlooze is Chief Technical Officer of LAB Motion Systems. It has a workforce of about 30 persons.

- **Surface Engineering (1988-2013)**

In 1971 prof.dr.ir. J. (Jef) Roos (*1943), then a lecturer, initiated surface engineering activities at KU Leuven. Since 1988 a Surface Engineering Group within the Department of Metallurgy & Applied Materials Science (MTM) existed. Activities as wear and friction modelling of coatings and surfaces evolved into the study of fretting and tribo-corrosion mechanisms. The main driving force in tribology activities in this group at Leuven is prof.dr. J.-P. (Jean-Pierre) Célis (*1947). By the end of the 1990's the workforce grew to about 20 persons . Numerous dissertations and publications were the result. By 2013 Jean-Pierre Célis retired, and tribology no longer is the major theme. In the years 2005-2010 applied research was transferred to Falex Tribology, another spin-off from Leuven, see below.

- **Friction Research (1994-2016)**

Prof.dr.ir. R. (Rik) Van Brussel (*1944), prof.dr.ir. J. (Jan) Swevers (*1963), and prof.dr.ir. F. (Farid) Al-Bender introduced friction research at KU Leuven in 1994, in the Department of Mechanical Engineering. Their friction models were heuristic and physics-based and were about pre-sliding (hysteresis) and gross sliding (friction lag), rubbing and rolling. This resulted in the Leuven integrated friction model, a generalised Maxwell-slip (GMS) model, and several studies on pre-sliding hysteresis dynamics. They earned important international recognition. The retirement of Farid Al-Bender in 2016 marked the end of these activities.

- **Falex Tribology (1999 - present)**

Falex Tribology starts in 1999 in Haasrode (B) as a spin-off from KU Leuven. It is a joint venture between Leuven University and the American Falex Corporation. At that time Dr.ir. D. (Dirk) Drees (*1965) and J.H. (John) Williams are leading the company as manager and managing director, resp. The activities grow and the company moves into a larger testing area, which is found in Rotselaar. Since 1999, Jean-Pierre Célis has served as scientific advisor. As of 2006, Dirk Drees is the CEO. Nowadays, the workforce amounts 7 persons and 1 scientific advisor. Main activities are: tribological testing to specifications, development of test equipment, development of test plans and customised test projects for industrial applications. Within the BeNeLux, this is the only commercial company where a wide range of tribological tests can be carried out.

3.13. Tribology activities within ASML Veldhoven (2010 - present)

Advanced semiconductors material Lithography (ASML) was founded in 1984 as a joint venture between Philips and Advanced Semiconductor Materials International (ASMI)[6] to commercialise the Philips SIRE III wafer stepper. Since then, the company has grown enormously and is the flagship of the high-tech industry in the Netherlands. As the chips need to be smaller and smaller, knowledge of physics at small scale, as with friction, is becoming more and more important. An essential part of the required knowledge is tribology. For almost 10 years, tribology activities became therefore extremely important.

At ASML, tribology activities are currently divided between three areas (Van Kuilenburg, 2019):

- the Tribology & Surface Engineering Group within Design & Engineering, with 8 academics, and the Test & Measurement group with 4 test engineers.
- the Flow, Thermal & Tribology Group within ASML Research, which has about 4 academically trained tribologists.
- the Contact Dynamics Group within the research institute Advanced Research Center for Nanolithography (ARCNL), in which ASML is involved, headed by prof.dr. S. (Steven) Franklin. In this institute, there is a lot of opportunity for research that will only be of long-term value.

Tribologists at ASML spend almost all their time on the “wafer table” and the “wafer clamp”. As a consequence, currently important topics are:

- protective coatings (PVD, CVD)
- wear and lifetime
- friction, especially in vacuum
- roughness
- contact modelling

6 Note that ASMI is different than ASML.

ASML's tribologists publish very little because of the enormous importance of this research for the company, and the great competitiveness in the world of chips. Because of the many fundamental problems that still need to be solved, also in the field of tribology, it is to be expected that tribological research at ASML will continue for a long time and with great intensity. It is not daring to say that tribology has a great future here for years to come.

3.14. Summarizing the roles of these institutes

The very first institute in the foregoing list started in 1927 with experiments on journal bearing friction, and nowadays explores friction in mechanical components for space applications (Liège University). The last institute in the list is the world leader in manufacturing chip machines and investigates friction at the nanoscale (ASML). In between, there are or were a whole slew of institutes that have emerged and some that have died out. Recent spin-offs from KU Leuven are working successfully in the highly competitive market of high-tech products.

In short, tribology has a clear past, is very much alive and has a bright future.

4. Tribologists from the Low Countries, from 1590 onwards – the people behind the history

This chapter discusses various individuals who have had an important influence on the development of tribology in the Low Countries, from around 1600 to the present day.

The *History of Tribology* (Dowson, 1979) contains a wealth of information on global and regional developments that were important to tribology. In the Renaissance (ca. 1450-1600), tribology becomes clearly identifiable as a scientific activity in which systematic research should lead to a better understanding of friction, particularly in the work of Leonardo da Vinci (Dowson, 1979, pp. 96-109, 530-532). In the intervening period (1600-1750), before the Industrial Revolution, Dowson pays attention to the Dutch windmill, without mentioning names. There are historians who claim that the glory days of the Netherlands, the Golden Age (1590-1700), can be traced back to the invention of the wind-powered sawmill. The name Cornelis Cornelisz is intrinsically linked to this (section 4.1). In the Golden Age, science was also at a high level and world-famous scientists were active in the low countries, such as Petrus van Musschenbroek. His name deserves a place alongside those of Amontons and Coulomb (section 4.2). Other scientists who made important contributions lived in the 20th century, when tribology began to flourish, and the present. The order chosen in the description is by year of birth.

4.1. Cornelis Cornelisz. van Uytgeest (ca. 1550 - ca. 1605)

Historians point out that the Dutch sawmill triggered a revolution in industry that is quite comparable to the Industrial Revolution 1.0 with steam power in England (1750-1850). It enabled the Golden Age in the Netherlands and could rightly be called the Industrial Revolution 0.0, using wind power. Cornelis Cornelisz. Van Uytgeest (1550 - ca. 1605), born in Uytgeest (North Holland), is the inventor of the crankshaft with an arbitrary number of cranks, for application in a sawmill. A bearing-mounted crankshaft is the prime example of a classical tribo-system.

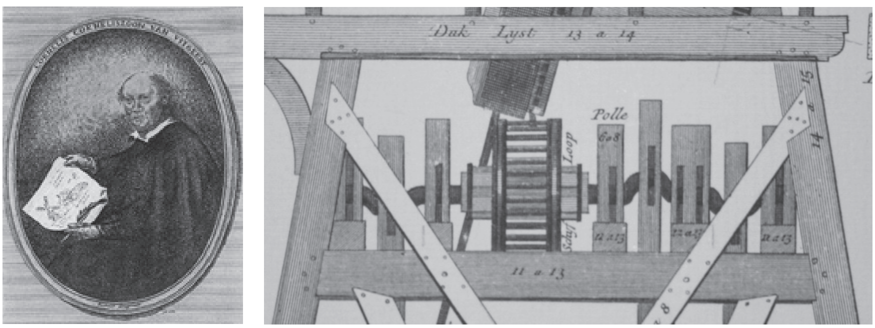


Figure 4.1: Cornelis van Uytgeest (left) and Dutch windmill crankshaft (right), source: Van Natrus et al., 1734

Cornelisz. is known for several patents. The second patent, from 1597, is the most important for tribology. This patent allowed for driving many wood saws simultaneously (N.N., 1597). Figure 4.1 shows a crankshaft from a Dutch windmill (Pfalzrock type). Until then, there was only the eccentric. A crankshaft with two or three cranks was an amazing technological breakthrough.

4.2. Petrus van Musschenbroek (1692-1761)

Petrus van Musschenbroek was the son of an instrument maker from Leiden (South Holland). He developed all kinds of scientific instruments for others and for himself, which he built together with his brother Jan and other Leiden instrument makers. After his studies and two doctorates in Leiden, he became a professor successively in Duisburg, Utrecht and Leiden.

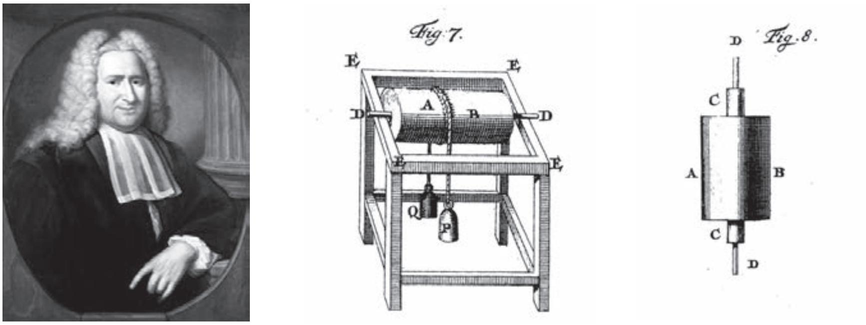


Figure 4.2: Petrus van Musschenbroek (left), his tribometers (in the middle) and a detail showing the drum on the shaft (right), Van Musschenbroek 1736).

Van Musschenbroek studied with Isaac Newton and John Theophilus Desaguliers in London. He is famous for the invention of the 'Leyden jar' and did many experiments with electricity, magnetism, mechanics and friction. For the latter he built himself an instrument which he called a 'tribometer', see Figure 4.2 (Van Musschenbroek, 1734, 1736, 1739 and 1747).

This device could measure the friction in sliding bearings at different loads and speeds. He considered it the best he had ever seen. From the books cited, the very surprising conclusion can be drawn that Van Musschenbroek had already measured two Stribeck curves before or in 1734, without knowing it himself and without it ever being noticed by others (Stribeck, 1902). They are the frictional torques of a contact between a steel shaft in two semi-sliding bearings lubricated with olive oil, in which two different types of cupper could be used, see Figure 4.3.

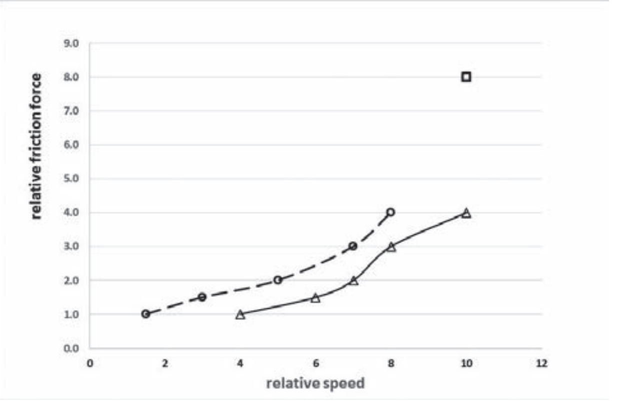


Figure 4.3: Relative friction force with relative speed (Van Musschenbroek, 1769). Legend: □ and —o—o—steel on red cupper, dry; —Δ—Δ— steel on red cupper, lubricated (see Van Leeuwen, 2021)

He was the first to find that the coefficient of friction behaved too inconsistently to conclude that it is constant, as Da Vinci (1:4) and Amontons (1:3) wrote. He found much higher and much lower values, as it should. Petrus van Musschenbroek therefore deserves a place in the list of the most important tribologists worldwide, alongside Amontons, Desaguliers and Coulomb.

4.3. Geert Salomon (1906 - 1985)

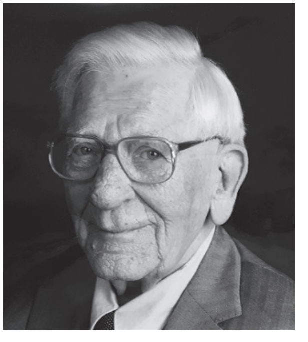
Geert Salomon was born in Frankfurt (D) in 1906. After studying physical chemistry in Munich and Berlin, he obtained his doctorate in 1933 with Herbert Freundlich at the Kaiser Wilhelm Institute for Physical Chemistry and Electrochemistry in Berlin-Dahlem in the field of colloid chemistry. Via the ETH (Eidgenössische Technische Hochschule) Zurich and the University of Reading (UK), he joined the research laboratory of the Dutch rubber industry in The Hague in 1938. There he was mainly concerned with the mechanical behaviour of rubber and plastics. He dealt with questions of adhesion, fracture and wear of rubber.

After the Netherlands left Indonesia at the end of 1949, rubber imports came to an end. Salomon looked for and found a new job at TNO in The Hague. His interest in wear led him to co-organise the first major wear conference in Europe in 1951. He became director of the TNO Rubber Institute and later one of the directors of TNO's Central Laboratory. Geert Salomon was the first editor of the Elsevier magazine "Wear".

His contribution to tribology in the Low Countries should certainly not be underestimated. He was very creative and made many suggestions to the Bond voor Materialenkennis, both asked and unsolicited. He is also, together with Horst Czichos, the driving force behind the systems approach in tribology. His are the words (Salomon, 1964):

"We, as a group of specialists, know that the coefficient of friction is only a convenience describing a friction system and not a material property."

4.4. Harmen Blok (1910-2000)



Harmen Blok was born on 8 September 1910 in Amsterdam. His father, Pieter E.J. Blok, had no academic training, but did have an intuition that, combined with his experience as a shipbuilder, made him see all sorts of physical relationships in his environment. Harmen inherited this custom and referred to it as the 'associative approach'. He sees the *associative approach* as his most important source of inspiration and legacy at the same time (Blok, 2001).

Harmen studied mechanical engineering at the then Technische Hogeschool Delft from 1928 to 1932. From 1933-1951 Harmen worked at the "Delft Laboratory" of the Royal Dutch/Shell group in Delft (later Rijswijk). The young Harmen entered the field of tribology under director Gerrit Boerlage (1885-1938), who invented and patented the 4 ball apparatus, an important test method in tribology (Boerlage, 1933).

From 1951-1981 Blok was a professor of tribology, which was initially called "Machine elements" and later "Machine elements and Tribotechnology", see section 3.4.

During his professorship, Blok maintained many international contacts and travelled extensively. According to an overview provided by Blok, 76 students graduated under his supervision. After his retirement, he remained active with consulting work for industry, visiting conferences and scientific research. His graduates continued to visit him faithfully and they would talk about tribology. He remained devoted to the discipline until his death on 16th August 2000 in his hometown, Rijswijk.

Harmen Blok's achievements in the field of tribology are numerous. He definitely is one of the "giants" in the tribology. He won almost every award and medal in tribology imaginable, including the Georg Vogelpohl Ehrenzeichen from the German *Gesellschaft für Tribologie* (GfT) in 1991. A comprehensive study of Harmen Blok's significance for tribology is in preparation (van Leeuwen, to be published).

4.5. Evert Muijderman (*1931)

Evert Muijderman was born on 3 February 1931 in Hedel (Gelderland). After studying mechanical engineering at the Technical University of Delft (1949-1956), he joined Philips at the NatLab (short for the Physics Laboratory, in Dutch) in Eindhoven. That was something special, as there was almost no demand for mechanical engineers in the lab. There was little tribological tradition in the Netherlands at that time. After all, Blok had only been a professor in Delft for a few years.

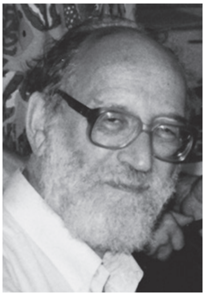
Muijderman chose to study the problem of thrust bearings, as appearing in consumer turntables, but also in of ultracentrifuges [7]. A series of experiments with grooved bearings, built with technical intuition by the workshop, were successfully completed. On this he built a theory, which he completed with a cum laude doctorate in 1964 with Harmen Blok (Muijderman, 1964), on the spiral groove bearing (SGB).

Evert Muijderman was above all the person who gave the spiral groove bearing its theoretical basis, further developed it and became its great promotor. The spiral groove bearing became an enormous success, first in medical applications and in consumer electronics (X-ray tubes and video cassette recorders, VCRs). Since the beginning of this century, it can be found in almost all hard drives produced, resulting in a total production of over 20 billion SGB bearings.

7 This is an application to enrich uranium, a hot item in that time of the Cold War

From 1970-1985 Muijderman was part-time professor of tribology at the TH Delft, in Harmen Blok's WO&TT Group. From 1988-1996 he was part-time professor of tribology at Eindhoven University of Technology. From 1980 to 2000 he was often associated with the Technical Academy of Esslingen as a lecturer in many courses. For all his achievements he was awarded the Georg Vogelpohl Ehrenzeichen from the German *Gesellschaft für Tribologie*, (GfT), in 2020.

4.6. Joost Kalker (1933-2006)



J.J. (Joost) Kalker is born on July 25th, 1933, in a Jewish family in The Hague. His father is a GP, his mother a dentist. In 1951 he becomes a freshman at the TH Delft, in the then new Department of Applied Mathematics. He finished his M.Sc. thesis on rail contact mechanics in 1957, in the Group of prof.dr. R. (Reinier) Timman, During this project dr.ir. A.D. (Ton) de Pater, a scientist of the national Dutch Railways, was his supervisor.

From 1960 onwards Joost worked continuously on further understanding the friction between train wheel and rail. First as an assistant professor, and after obtaining his Ph.D. in Applied Mathematics in 1967 under professors Timman and De Pater, since 1979 as a full professor holding a personal chair, within Applied Math.

Joost became world-famous as an expert on railway contact mechanics and was much in demand as a consultant. He wrote several books on this subject and his computer codes to calculate friction are still state of the art. He supervised 6 Ph.D. students.

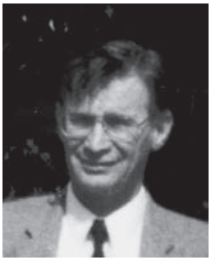
The laboratory in Delft ceased to exist by the end of the 1990s. Joost retired in 2002.

4.7. Ton de Gee (*1933)

Ton de Gee began his career in 1958 in the wear group of ir. J. Beekhuis, which was part of the Metaalinstituut of TNO, then located in Delft. In 1963 he became head of the new Department of Surface Treatment and Tribology (OBT). In 1972, the Metaalinstituut moved into a new complex in Apeldoorn. It was here that the research work of De Gee's group really blossomed. Together with Begelinger and Salomon (TNO), Czichos (BAM) and Landheer (TU/e) he developed the IRG-OECD transition diagram.

Ton de Gee became a part-time professor at TU Delft (1985-1995) and also at the University of Twente (1987-2002). His importance for tribology at UT is great, as he is the link between the era of full-time professors Bosma (1965-1988) and Schipper (since 2002).

4.8. Gerard van Heijningen (1934 - 2003)



Gerard van Heijningen was born in The Hague on 18 March 1934. After completing his studies as a physics engineer at the TH Delft, he joined Harmen Blok as a research assistant in 1972. Under Blok he worked on the spin-off cooling of gears, which was also the title of his dissertation (Van Heijningen, 1981). He took early retirement in 1996.

Van Heijningen introduced Blok's basic rules for design at the Faculty of Mechanical Engineering and wrote a number of textbooks about it (Van Heijningen, 1993). He also endeavoured to introduce Blok's flash temperature determination as a standard tool in DIN gear calculation and that Harmen Blok's most important publications be published in a book with CD ROM. This was announced at the second World Tribology Congress WTC 2001 in Vienna. At that time Van Heijningen was already ill. He died in 2003. Harmen Blok himself created the concept before his death, which is available in a slightly modified form from the Professor Harmen Blok Foundation (Blok, 2001) [8].

4.9. Hans Moes (*1936)

Hans Moes was born in Amsterdam on 8 July 1936. After studying mechanical engineering at the university of applied sciences (HTS Amsterdam), he decided to continue his studies at the TH Delft. For his degree he chose the group of Harmen Blok.

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[8] It can also be obtained in digital form from the author.

Blok hired Moes in his group after graduation. There Moes worked on dynamically loaded bearings and elasto-hydrodynamic lubrication (EHL) theory. His contribution to the EHL line contact discussions (Moes, 1965) was widely quoted. Here he already shows to be a master in using nondimensional groups and approximation formulas.

Roel Bosma persuaded him to come to TH Twente in 1967, where he taught tribology and worked on many topics, most of them in the field of hydrodynamic lubrication. Hans Moes took early retirement in 1997. He compiled almost all his tribological knowledge, such as his lecture notes, in his book *Lubrication and Beyond* (Moes, 2000), which deals with many aspects of hydrodynamic lubrication. It has a fundamental approach, so it will not be quickly out of date.

4.10. Kees Roelands (*1936)

Kees Roelands was born on 12th of July1936 in Princenhage (near Breda, in North Brabant). He graduated in 1960 under prof. J.C. Vlugter in the Department of Chemical Technology at the TH Delft. The subject was the viscosity of lubricating oils at high pressure. Immediately after graduation, he contacted Harmen Blok, who agreed to supervise in continuing his investigations on fluid viscosity, together with Vlugter. He did this in addition to his work as a researcher at Akzo-Nobel. This doctoral work culminated in a much-cited dissertation, which Roelands completed summa cum laude (Roelands. 1966).

After working at the National Defence Organisation TNO from 1961-62, Roelands continued his career at Akzo Nobel from 1962. He took early retirement in 1994.

4.11. Carl Dekoninck (1937-2021)

Carl Dekonick was born on 11th November of 1937 in Leopoldsburg (Belgian Limburg). He became lecturer at Ghent University in the Engineering Faculty in 1971. He taught tools and manufacturing, and at the time the demand for improved machine accuracy was increasing. This led to the application of hydrostatic bearings, known for their accuracy, to support the machine's shaft, and to a research programme where extensive computer calculations were performed. Compared to his colleagues, he and his assistant Michel Vermeulen used the digital computer in a very early stage. See also under section 4.11.

Dekoninck introduced tribology to Ghent University and taught a tribology course, where he lectured in hydrodynamic lubrication from the books by Cameron (1966) and Halling (1975). He started the Laboratory of Machines and Machine Construction (LMM). In 1977 he was appointed as professor, and in 1981 as a full professor and held the chair of Mechanics of Flow, Heat and Combustion from 1992-1998.

Together with Prof. Walter Soete (Soete Labo), he worked in many projects for Belgian industry to solve large tribological problems, such as extremely large bearings for the storm surge barrier in the Scheldt river. For this purpose, he had a giant tribometer designed and built, the Large Scale Tester (LSF, see Figure 3.13). The legacy of this lab is that it is the only place in Europe where large tribological systems can be tested under (almost) real conditions.

He retired in 2003. He passed away in Ghent on 10th of May, 2021.

4.12. Summarizing the tribologist portraits

For the Netherlands, more than for Belgium, tribology always had a strong international orientation. No wonder that Dutch tribologists met most often outside the Netherlands, see Figure 4.4.

Figure 4.4: At the 15th Leeds-Lyon Symposium, September 1988, at the Bodington Hall campus in, Leeds. From L to R. Standing, Carel Thijsse, Marnix Visscher, Cokkie Kalker-Kalkman, Gerard van Heijningen, Evert Muijderman, Ton Tangena, Harmen Blok, Peter Holster. Kneeling, Harry van Leeuwen, and Arno Kanters.

As the previous subsections show, the development of tribology is written by real people of flesh and blood. This is what makes writing a tribological history so fascinating. The list ends with 1937 as the year of birth. More names will follow in the future, if someone feels inclined to update this history.

5. The future of tribology in the Low Countries

The role of tribology is no longer considered important in many traditional Dutch companies. Many companies outsource their tribological activities, even the large ones. The major exception is ASML, see section 3.13. The problems that arise here are very fundamental and a matter of long-term perspective. A lot of money is available to solve them. In contrast to other companies such as Philips, Océ and Shell, a considerable number of highly trained tribologists will be needed here for a long time to come. Research is outsourced by these companies to the technical universities, such as the tribology groups at UT, or at the Ghent University.

The generation of Harmen Blok's "grandchildren" is still working at these universities. But here, too, a new generation has been and is being, trained, the third one, ready to continue the tribological tradition of the Low Countries. To this end, the seed was sown by Professors Blok, Bosma, Dekoninck and Muijderman. The Low Countries are well prepared for the future thanks to a tradition of good tribological education since 1960. It gives rise to a hopeful extrapolation: there are already new tribological torchbearers. In 50 years' time, history will again reveal what was important in this context.

History is past. The future is calling.

6. Conclusions

At first sight, the history of tribology of the low countries seems to be quite young. But important tribological approaches can already be found in a distant past with Cornelis Cornelisz (around 1600) and Petrus van Musschenbroek (around 1740).

The founding of the "Lubricants and Lubrication" Kring as the forerunner of the Tribology Section did not take place until 1942. Since the 1950s, hundreds of engineers have been trained as tribologists. The role of prof.ir. H. Blok of TU Delft was decisive in this. This leading role has been taken over in this century by the tribology groups of the Universities of Twente and Ghent.

The development of tribology in industry shows that it is very much determined by the spirit of the times. From the 1950s onwards, several tribology groups (Philips, TNO, Shell, SKF) emerged, which were greatly reduced or completely abolished in the new century. In addition, a large new basic group is under construction at ASML, and spin-offs from KU Leuven are doing very well. The focus has also shifted from mechanical engineering to elementary physics. The tribology groups in the Low Countries are sufficiently equipped to prepare their students for this future.

Acknowledgements

This essay was written at a time when many "men of tribology" are still alive. The author knows most of them and was also lucky enough to have

personally known great tribologists of the recent past, as Blok, Salomon, Van Heijningen and Bosma.

Many people were consulted to write this piece of history. Without being exhaustive, a few names must be mentioned. Those of Farid Al-Bender, Henk Blok, Jean-Pierre Célis, Dirk Drees, Julien van Kuilenburg, Hans Moes, Evert Muijderman, Ton de Gee, Gerhard Poll, Kees Roelands, Arend Schwab, and Michel Vermeulen.

I am very grateful to former Shellist and ex-colleague Eduard Laukotka for inviting me to write this tribology history. Otherwise, it would not have occurred.

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Laudatio Youssef Cassis

Frank Caestecker

In October 2018, as the professor of economic history of the faculty of economics together with Prof. Schoors and Prof. Vander Vennet of banking and finance I had proposed to invite Youssef Cassis for the Sarton lecture of the academic year 2019-2020 to the council of the faculty. Since 2011 Prof. Cassis has been Professor of Economic History at the European University Institute in Florence, before he had held similar academic positions at the University of Geneva, Switzerland and at the University Pierre Mendes France in Grenoble, France. His research on banking and financial history is well known, among historians as well as economists.

We were very thrilled that Youssef Cassis agreed to give a lecture on "Europe's Financial History in the Twentieth Century" on Wednesday 6th May 2020. However, due to Covid, the lecture was postponed until Wednesday May 5th, 2021. However in May 21 the covid virus was still circulating dangerously. We were not yet collectively protected as only part of the population had been vaccinated. Staff and students were not protected yet. Therefore we were forced to postpone Prof. Cassis' lecture again we set a new date for the following year, but a day earlier than in 2021, on May 4th . The third time a charm. Finally Prof. Cassis is among us here in Ghent for his Sarton lecture of the academic year 2019-2020.

It is a honour to give an introduction to present the works of Youssef Cassis. I know him from the last century when we published articles together in a German book about *Der Mensch des 19. Jahrhundert*. The book offered a social history of certain groups typical of the 19th century. I wrote about migrants and he about managers and entrepreneurs. Youssef Cassis has a profound knowledge of the 19th century economic elite. His Ph.d. supervised by one of the most important historians of the 20th century, Eric

Hobsbawm had been dedicated to the bankers of the City of London during the Belle Epoque. In the early 1980s he had made a prosopography of the financiers of the City of London at the turn of the nineteenth and twentieth centuries. He made a social study of this social group through the careful compilation of personal data. The book was a collective biography of the careers of the 460 bankers of the City, he reconstructed their education, marriages, parliamentary positions and membership on company boards.

He showed with this prosopography that in Britain of the Belle Epoque finance and industry were two separate worlds. The financial world was socially closer to the aristocracy, the landed elite than to the business world. This was not only a social, but also an economic reality. There was hardly any interest of the financial actors of the City to invest in industry.

Can the very limited interest of the British financial market in industry help us to explain why Britain lost at that time its industrial leadership in the world to the United States and Germany. Britain lost its title of workshop of the world and of Europe to Germany. While Britain had started the First Industrial Revolution, with the Second Industrial Revolution Germany became the workshop of Europe. In Germany finance and industry were very closely intertwined. The combination of financial and industrial capital had made Germany's Second Industrial Revolution possible and Britain lagged behind in industrial innovation. Britain was not bereft of innovation as its service sector and the City were thriving. By the end of the 19^{th} century Britain was still the prosperous nation of Europe as it had become the office of the increasingly more globalized world of the Belle Epoque. The faster growth of the German economy was not enough to fill the gap. Britain still remained a larger economy with a higher per capita income.

After his focus on the microcosmos of the city of London, Youssef Cassis broadened his horizon in the 1990s with a European comparative project on big business. He listed companies with a workforce over 10.000 in Britain, France and Germany, from the 1920s to the 1950s. Throughout the whole time period Britain was in the lead, with more large firms in more sectors of the economy than in France or Germany.

Although Britain's overall economic performance after the Second World War declined as its growth rates were lower than in France and Germany this was not the case for British big business which performed better than other British companies. Cassis concluded that for these big business British success, not failure, needed explanation.

The European comparative approach showed however than what characterized these three national cases the most was convergence, a convergence between industrialized nations, and this meant catching up with the British leader for France and Germany and even overtaking Britain in the 1960s, but in the 1980s Britain caught up with them again.

In his conclusion Youssef Cassis pointed out that Britain's greatest comparative advantage was in finance and his research went back to the financial economy. In the two first decades of the 21th century he published several books with a comparative and comprehensive historical overview of long term developments of the financial economy.

His book of 2006 *Capitals of Capital: A History of International Financial Centres since the late eighteenth century* was a comprehensive overview of the developments of the main centers of capital: London and New York, Amsterdam and Brussels, Zurich, Paris, Frankfurt and Tokyo. The book explains the rise and decline of financial centres in modern history. Concomitant with a country becoming a world economic leader the financial actors of that country took seized the opportunity to become the *International Financial Centre.* His argument is that the size of the domestic economy is the most important long-term driver of an International Financial Centre. The strength of the national currency was also a factor. Zurich profited from the strength of the Swiss franc and the City suffered from the difficulties which Sterling had since the end of the First World War. More recently, in the era of floating rates and globalization of capital, the strength of the national currency became much less important for being a leading financial centre. Another factor –linked to his interest in the human dimension of economic development- which Youssef Cassis underlined as an important long term factor is the capacity of a financial centre to attract outside talent. This international openness to financial professionals is important as it brings along innovation. From the 1970s onwards the City of London became dynamic as foreign banks settled there and, American, European and Japanese expatriates became part of the British financial world.

Cassis downplayed or rather is skeptical of the role of the state and regulation on the fortunes of *International Financial Centres*. While it has been argued that the resurgence of London as a financial centre was due to the weak regulatory regime of London (in comparison to New York) and the opportunities it offered for the Eurodollar market, Youssef Cassis suggests that state intervention 'rarely determines the destinies of international financial centres in a lasting or fundamental way'.

The global financial crisis of 2008 triggered Youssef Cassis to make a historical survey of the influence of financial crises on the financial economy. Others did too, for example *This time is different* of Reinhart and Rogoff. Youssef Cassis' contribution, *Crises and Opportunities, the shaping of Modern Finance* of 2011, shows how financial actors and regulators have shaped and reshaped the financial economy during crises. How the financial economy is an ever changing economic domain. The financial regulations inherited from the most notorious financial crisis, the Depression of the 1930s, have worked well for three decades. There were no financial crisis until the early 1970s. After the breakdown of the Bretton Woods regime, a major shift in financial markets occurred with the emergence of floating currencies and greater capital flows. The number of banking crises rose spectacularly and culminated in the financial crises of 2008.

As Youssef Cassis rightly argues, the return to the old solutions of the post war era which has worked perfectly for three decades feels comfortable, but is not always the right solution. The world and also the financial economy have changed. In the early 21th century the economic weight of the financial sector has increased tremendously, also the global character of financial activities is much more pronounced than at the time of previous crises. A blind returning to old solution can be similar to generals preparing for fighting the previous war and losing the battles.

Youssef Cassis masters the "métier" of a historian, trying to understand how the world changes and to learn from the past in a flexible manner. In a flexible manner as the world of today is different form the world of yesterday.

During the three years that we have been trying to get Youssef Cassis to come to Ghent for this lecture he has not been idle. He has started a new project 'The Memory of Financial Crises: Financial Actors and Global Risk'. It is a study of how earlier financial crises and in particular the crisis of 2008 have affected the thinking and behavior of financial actors and regulators. A research which has some resemblances to his collective biographies of 1984, but now to understand how these actors make decisions to shape and reshape the financial system.

This overview of the research of Youssef Cassis gives you an idea about his intellectual trajectory. His profound knowledge of the history of the economy and the financial economy in particular makes him the perfect candidate for an insightful historical overview of the 2Oth century financial economy in Europe.

Europe's Financial History in the Twentieth Century

Youssef Cassis

Introduction

Financial history is often regarded as the narrowest and most specialised area of history. But much the opposite is actually the case. Financial history touches all aspects of human endeavour, whether economic, social, political, or cultural. Old and new interests include the role of finance in economic development; monetary systems and monetary policy; the business of banking; international finance, in its multifaceted dimension; financial crises, financial elites; and many others.[1]

Europe occupies a major if not a central place in this field, and a vast literature has been devoted to the diverse aspects of its financial history. And yet hardly any work has been devoted to the financial history of Europe as such. The major exception is Charles Kindleberger's classic book, *A Financial History of Western Europe*, first published in 1984 –at once a work of reference and an interpretative essay.[2]

The scope of this lecture is more limited. How to make sense, within the framework of an article, of Europe's financial history in the twentieth century? Beyond the multiple events, countries, institutions, markets, and people that have marked this turbulent period, this history is best reflected in

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1 For a historiographical survey of the sub-field of financial history see Y. Cassis and P.L. Cottrell, 'Financial History', in *Financial History Review*, 1, 1 (1994), 5-22; and Y. Cassis, 'Financial History and History', in Y. Cassis, R. Grossman and C. Schenk, *The Oxford Handbook of Banking and Financial History* (Oxford, Oxford University Press, 2016), 17-40.

2 C.P. Kindleberger, *A Financial History of Western Europe* (London, George Allen and Unwin, 1984).

two major trends. The first is related to Europe's position in global finance: it can be described as a history of relative decline. The second is related to the relationships between Europe's constituent parts: it can be described as a history of limited convergence and integration.

Before discussing each of these trends, a word about chronology. The twentieth century will be considered, in a traditional way, as beginning around 1900 and ending around 2000. Historians have proposed other chronologies. But Eric Hobsbawm's 'short twentieth century', for example, between 1914 and 1991,[3] is not well suited to Europe's financial history: both the years before 1914 and after 1989 must be taken into consideration. Both were periods of globalisation, as well as deregulation for the end of the twentieth century. And from a European perspective, 1999, the year of the introduction of the euro, provides an appropriate end date.

Four main periods in the twentieth century will be taken into consideration: the *Belle Époque*, between 1900 and 1914, a period of fast growth, imperial expansion, and monetary stability. The 'Thirty Years Wars of the Twentieth Century', between 1914 and 1945, marked by two world wars and the most severe depression in modern history. The 'Golden Age', between 1945 and 1973, when Europe enjoyed the highest growth rates in its history. And finally, the era of deregulation and globalisation that characterised the last quarter of the twentieth century.

Relative decline

Let us start with relative decline. In the late nineteenth and early twentieth century, Europe was the world's banker –to use the title of Herbert Feis's pioneering study.[4] The turning point in Europe's fortunes is usually considered to be the First World War –thus relatively early in the twentieth century. Comparisons are of course with the United States –Asian competition only seriously started in the twenty-first century.

Feis was primarily interested in foreign investment and the relationships between finance and diplomacy, but it is also worth considering three other

[3] E.J. Hobsbawm, *Age of Extremes. The Short Twentieth Century, 1914-1989* (London, Michael Joseph, 1994).

[4] H. Feis, *Europe, the World's Banker, 1870-1914* (New Have, Yale University Press, 1930).

domains of European finance: financial centres, financial institutions, and financial innovation.

Foreign investments

On the eve of the First World War, over 90 percent of the stock of foreign assets (about $46 billion) were held by European countries, with Britain clearly in the lead (with 43 per cent), followed by France (21 per cent), Germany (13 per cent), and a group of small and wealthy countries including Belgium, the Netherlands, and Switzerland (together with 12 per cent). The United States only held 8 per cent of the total, mainly in the form of foreign direct investment.[5]

But the United States was also the largest recipient of foreign investments, with some 14 percent of the total, well ahead of the largest emerging economies of the time, mainly in the Americas (Canada, Argentina, Brazil, Mexico) and Asia (India, China). Three European countries were large importers of capital: Russia, in second position behind the United States, Austria-Hungary, and Spain.[6] Altogether, the United States' foreign liabilities exceeded its foreign assets by $3 billion.

Within a few years, the position of the United States had radically changed: from being a net debtor it became a substantial net creditor, to the tune of $4.5 billion in 1919. Europe, admittedly, was no longer the world's banker. Or was it? The answer is not as simple as usually assumed. First, Britain, France and Germany together lost more than a third of their foreign investment –some $12 billion. But while Germany lost all its foreign assets, and France most of them, probably three quarters, mainly in Russia, Britain only lost part of them, about 15 percent.[7]

Second, Britain remained the largest holder of foreign assets, with about the same percentage of the total in 1938 as in 1913 (42 per cent), ahead of the United States, now in second position with 22 per cent. France had fallen to fourth position (with 7 per cent), behind the Netherlands (14 per-

5 United Nations, *International Capital Movements during the Interwar Period* (New York, 1949).

6 M. Schularick, 'A tale of two globalizations: capital flows from rich to poor countries in two eras of global finance', in *International Journal of Finance and Economics*, 11, 3 (2006), 339-54.

7 C.H. Feinstein and K. Watson, 'Private International Capital Flows in Europe in the Inter-War Period', in C.H. Feinstein (ed.), *Banking, Currency and Finance in Europe Between the Wars* (Oxford, Oxford University Press, 1995), 98.

cent), while Germany hardly held any foreign assets. Altogether, Europe still held some 70 per cent of the total.[8]

The main, and essential, difference was in terms of capital flows, as opposed to capital stocks. Here, the United States was the largest provider of capital worldwide: during the second half of the 1920s, almost 60 per cent of capital exports came from the United States, and about 15 per cent each from Britain and France.[9] However, international capital flows virtually came to a halt in the 1930s, from the United States even more than from Britain, with serious consequences for the world economy.[10]

The United States reached a position of overwhelming financial dominance in the aftermath of the Second World War, though during a period of limited international capital movements. Europe made up lost ground during the 'Golden Age' and after. By the end of the twentieth century, the United States were the largest holders of foreign assets, with 26 percent, ahead of Britain (15 per cent), Japan (10 per cent) Germany (9 percent) and France (8 per cent).[11]

Decline was thus not only relative. It was also uneven, depending on periods, countries, and type of financial activities.

Financial Centres

This is corroborated by the development of international financial centres, which presents a similar though not identical picture. Before 1914, London was the undisputed financial centre of the world, well ahead of its rivals in most if not all financial services: trade finance, discount market, foreign issues, stock exchange, commodity markets, insurance, accounting and legal services. And the Bank of England was the conductor of the international monetary system, the gold standard, based on the pound sterling.[12]

8 Feinstein and Watson, 'Private International Capital Flows'.
9 Feinstein and Watson, 'Private International Capital Flows'.
10 B. Eichengreen, 'The Origins and Nature of the Great Slump Revisited', *Economic History Review*, 45 (1992), 213-39.
11 M. Obstfeld and A. M. Taylor, *Global Capital Markets. Integration, Crisis and Growth* (Cambridge, Cambridge University Press, 2004), 53.
12 Y. Cassis, *Capitals of Capital. A History of International Financial Centres* (Cambridge, Cambridge University Press, 2006), 83-101.

Paris has been accurately described by the historian Alain Plessis as a 'brilliant second',[13] on account of the strength of its long-term capital market, the weight of the big banks, and the stabilising role of the Banque de France in the functioning of the international monetary system. In third place, Berlin was dominated by the big universal banks in both international and industrial finance, and remained more inward than outward looking. Finally, New York emerged amongst the leading centres, in fourth place, around 1900, when the United States started to export capital.[14]

The First World War did not entirely change the pre-war order. London remained the world's preeminent financial centre, still offering an unrivalled range of financial services. During the 1920s, it was overtaken by New York solely in the field of foreign issues, one of its pre-war specialities. Paris fell in third position, but still harboured hopes of competing with London and New York in the late 1920s and early 1930s, on the back of its strong balance of payment.[15] Berlin, however, paid the price of Germany's defeat.[16]

New York replaced London as the world's leading financial centre after the Second World War, as a result of the position of the United States in the world economy and the dollar as the linchpin of the new international monetary system created at Bretton Woods. London was somewhat anaesthetised by heavy regulation and the travails of the British economy. But it did not disappear from the map: on a smaller scale, it continued to play an international role as the financial centre of the sterling area, retaining its markets, institutions and skills ready for a possible reawakening. Paris was only the shadow of what it had been only forty years earlier: even more than in Britain, the state's grip ended up stifling the Parisian capital market. And in Germany, Berlin was replaced by Frankfurt, which did not really take off before the 1960s.[17]

The City of London's revival started in the 1960s with the advent of the Euromarkets, which signalled the reopening of international finance in a still highly regulated financial environment.[18]

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13 A. Plessis, 'When Paris Dreamt of Competing with the City…', in Y. Cassis and E. Bussière (eds.), *London and Paris as International Financial Centres in the Twentieth Century* (Oxford, Oxford University Press, 2005).

14 Cassis, *Capitals of Capital*, 101-124.

15 P. Einzig, *The Fight for Financial Supremacy* (London, Macmillan, 1931).

16 Cassis, *Capitals of Capital*, 143-80.

17 Cassis, *Capitals of Capital*, 204-17.

18 C.E. Altamura, *European Banks and the Rise of International Finance. The post-Bretton Woods era* (Abingdon and New York, Routledge, 2017).

The Euromarkets are markets for transactions in dollars taking place outside the United States, free of American regulations. The Eurodollar market, a *short-term* money market, was the first to develop in the late 1950s. It expanded rapidly, supplied mainly by American multinationals and European central banks, and provided credit on a worldwide scale to finance international trade and other short-term loans.[19] The Eurodollar market gave birth, in the early 1960s, to the Eurobond market, a *long-term* capital market for the issue of dollar-denominated bonds in London rather than New York.[20] A third form of Eurocredit, *medium-term* this time, lasting from three to ten years, developed in the mid-1960s. These were international bank loans wholly financed by resources in Eurodollars, taking the form of syndicated loans bringing several banks together.[21]

London quickly became the natural home of the Euromarkets, attracting an increasing number of foreign banks, primarily though by no means exclusively American. London was well-equipped to host these new financial activities, not least because of the age-old experience of its bankers. The positive attitude of the British monetary authorities, in contrast to that of their European counterparts, also made a difference.[22]

London competitiveness was further enhanced by the deregulations of the 1980s, best epitomised by 'Big Bank' in 1986, and by the end of the twentieth century, it had become the world's leading financial centre for international transactions. London came top in cross border bank lending; foreign exchange trading; asset management; Eurobond issues; and number of foreign banks and representative offices.[23] However, if one includes domestic financial transactions, London had to cede first place to New York, and second place to Tokyo, because of the sheer size of the American and Japanese economies. This is visible in the respective size of the three cities' capital markets. In any case, it was New York which set the tone in international banking.

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[19] P. Einzig, *The Eurodollar System. Practice and Theory of International Interest Rates* (London, Macmillan, 1967); G. Dufey and I. Giddy, *The International Money Market* (Englewood Cliffs, N.J., NJ., Prentice Hall, 1978); S. Battilossi, 'Financial innovation and the golden age of international banking: 1890–1931 and 1958–81', *Financial History Review*, 7, 2, (2000), 141-75.

[20] I. Kerr, *A history of the Eurobond market: the first 21 years*, (London, Euromoney Publications, 1984).

[21] R. Roberts, *Take Your Partners. Orion, the Consortium Banks and the Transformation of the Euromarkets*, (Basingstoke, Palgrave, 2001).

[22] R. Michie, *The City of London. Continuity and Change, 1850–1990* (Basingstoke and London, Macmillan, 1992); D. Kynaston, *The City of London, vol. IV A Club No More 1945–2000* (London, Chatto and Windus, 2001); Cassis, *Capitals of Capital*, 223-25.

[23] R. Roberts and Kynaston D., *City State. How the Markets Came to Rule our World* (London, Profile Books, 2001), 246-7.

Unlike in 1900, London's position was now dependent on the massive presence of foreign banks, and financial operations were mainly conducted in foreign currencies, primarily dollars. Some commentators described the City as a 'financial Wimbledon', in comparison with the famous tennis tournament where, since the 1930s, the star players had almost exclusively been foreign.

Such opening to the world was the condition for the financial capital of a medium-sized economy to reach a truly global status. Other European centres were unable to successfully compete with London. Frankfurt's chances were boosted when it was awarded the seat of the European Central Bank in 1992, but to no avail; and Paris never really found a role in the new global financial order. While remaining major financial centres, they were increasingly relegated to the second tier of the 'capitals of capital', behind the 'big three' –London, New York and Tokyo–, even though Tokyo lost ground in the 1990s following the burst of the property and stock market bubbles.[24]

Financial Institutions

Looking now at financial institutions, especially banks, brings yet another perspective on Europe's financial trajectory in the twentieth century. Let's consider two variables: size and multinational expansion.

By the turn of the twentieth century, the United States was already the world's largest economy. It also had the largest banking system, measured by bank deposits –in both cases, larger than Britain, France and Germany put together.[25] And yet only two American banks appeared on the list of the world's thirty largest banks in 1913, measured by assets: National City Bank, in sixteenth position, and Guaranty Trust Company of New York, in twenty-third. The top ten were all British, French and German, with two exceptions: the Banque russo-asiatique, based in St Petersburg and controlled by French capital, ranked seventh; and the Société Générale de Belgique, ranked tenth.[26]

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24 Cassis, *Capitals of Capital*, 261-73; S. Sassen, *The Global City. New York, London, Tokyo* (Princeton, Princeton University Press, 2001); City of London Corporation, *The Global Financial Centres Index*, 1, 2007.

25 R. Sylla, 'From exceptional to normal: changes in the structure of US banking since 1920', *Financial History Review*, 27, 3 (2020), 361-75.

26 Ranking established by the author on the basis of the *Banking Almanac*, 1914. See also P.L. Cottrell, 'Aspects of Commercial Banking in Northern and Central Europe, 1880–1931', in S. Kinsey and L. Newton (eds.), *International Banking in an Age of Transition* (Aldershot, Ashgate, 1998).

The reason for this anomaly has to do with regulation. American banks were forbidden by law to open branches in a state other than the one in which they were registered; and certain states even decreed that all banks should be single unit banks. Small country banks kept part of their reserves in reserve-city banks, which themselves kept part of their reserves in central-reserve-city banks, all based in New York.[27] There was thus room for the latter's expansion, but more limited than for the largest European banks, which had networks of branches covering the entire country.

The British clearing banks dominated the scene in the interwar years, as a result of mega mergers in 1918 that gave birth to the so-called 'Big Five' (Midland, Lloyds, Barclays, National Provincial and Westminster),[28] and also the retreat of the French and German banks, partly as a result of devaluation and inflation.[29] Citibank claimed to be the world's largest bank in 1930, but it was in fact the Midland Bank.

American banks became the largest in the world in the 1950s and 1960s, led by Bank of America, First National City Bank and Chase Manhattan Bank, ahead of the 'Big Five' British banks, themselves followed by the French and German banks (Crédit Lyonnais, Société générale, Deutsche Bank).[30] However, this did not last very long: measured by assets, Crédit agricole was the world's largest bank in 1980, Sumitomo Bank in 1990 and Deutsche Bank in 2000 –though the largest American banks usually featured in the top twenty, and ranked better when measured by market capitalisation.[31] One could talk here of a reversal of financial relative decline.

27 R. Sylla, 'Shaping the U.S. financial system, 1690–1913': the dominant role of public finance', in R. Sylla, R. Tilly and G. Tortella (eds.), *The State, the Financial System and Economic Modernization* (Cambridge, Cambridge University Press, 1999) 249-70; E. White, *The Regulation and reform of the American banking system, 1920–1929* (Princeton, Princeton University Press, 1983).

28 F. Capie and G. Rodrik-Bali, 'Concentration in British banking, 1870–1920', *Business History*, 29, 3 (1982).

29 H. Bonin, *L'apogée de l'économie libérale bancaire française (1919–1935)* (Paris, Plage, 2000); B. Ambigapathi, 'La stratégie de cartellisation bancaire en France entre 1919 et 1925', in B. Desjardins and al., *Le Crédit Lyonnais 1863–1986* (Genève, Droz, 2003) ; H. Wixforth, 'German Banks and their Business Strategies in the Weimar Republic: New Findings and Preliminary Results', in M. Kasuya (ed.), *Coping with Crisis. International Financial Institutions in the Interwar Period* (Oxford, Oxford University Press, 2003).

30 Ranking established by the author on the basis of the *Banking Almanac*, 1954-1961.

31 *The Banker*, 1981, 1991, 2001.

Multinational expansion

But bank size is an imperfect indicator of financial clout. Multinational expansion offers an interesting complement. European banks started to expand abroad much earlier and on bigger scale than their American counterparts. In 1913, six American banks had a total of twenty-six foreign branches, as against 1,286 for the British banks and some 500 each for the French and German banks. These branches had mostly been opened in colonial empires and other less developed countries, where banking facilities were fairly rudimentary, in order to finance trade in these regions and obtain necessary foreign exchange. The situation had only marginally changed by 1960, with some 2,600 branches of British banks, and about 300 to 400 for French banks, as against 131 for American banks.[32]

The British banks were thus clearly in the lead. Their foreign branches mostly belonged to the so-called overseas banks, which had their head office in London but conducted their operations abroad, including the empire[33] –the best known example is probably the Hong Kong and Shanghai Banking Corporation, today known as HSBC. However, they soon started to lose their competitive advantage, especially where socialist regimes and economic nationalism prevailed.[34] At the same time, with the rise of the Euromarkets, multinational banks shifted their attention from developing countries to the financial centres of the advanced economies; and they became much more involved in wholesale banking than in retail banking.[35]

The leaders of this new wave of foreign expansion were the American banks: they went from having 131 branches abroad in 1960 to having more than 787 in 1980, to which must be added 943 foreign subsidiaries.[36] Moreover, their networks of branches were far more dynamic than that of the British overseas banks, since it was more concentrated in industrialised countries and in international financial centres. British multinational

32 See G. Jones, 'Banks as Multinationals', M. Wilkins, 'Banks over borders: some evidence from their pre-1914 history', and T. Huertas, 'US multinational banking: history and prospects', all in G. Jones (ed.), *Banks as Multinationals* (London, Routledge, 1990).
33 G. Jones, *British Multinational Banking, 1830-1990* (Oxford, Oxford University Press, 1993).
34 Ibid.
35 T. Huertas, 'US multinational banking', in Jones (ed.), *Banks as Multinationals*.
36 Ibid.

banks, and those of other European countries, had thus to adapt to these new market conditions, this time without the advantage of first mover.[37]

This was thus the decline of the nineteenth and early twentieth model of multinational banking, dominated by British and to a lesser degree French and other European banks, including Belgian and Dutch ones. The new model that emerged in the 1960s was, as in other financial areas, dominated by American banks.

Innovation

Financial innovation is a good sign of the dynamism of a financial system, despite their often destabilising effects on financial markets. There have been hundreds of innovations in Europe's financial history. Many innovative financial products have been designed in connection with specific transactions. 'Project bonds', for example, were designed after the Global Financial Crisis of 2008 for infrastructure related projects. On the other hand, the creation of some financial products, institutions and markets marked a real turning point in the development of the financial system – some would talk of a 'financial revolution'. Think for example of derivatives and securitisation in the late twentieth century.

The two great financial innovations of the nineteenth century took place in Europe: one is the emergence of the 'new bank', in the second third of the century; the other is the rise of finance companies in the last third.

The emergence of the new bank was the result of a combination of innovations: joint stock banks collecting deposits through a network of branches in England; investment banks with the Société Générale de Belgique and the Crédit Mobilier of the Pereire brothers in France; and universal banks, combining commercial and investment banking, in Belgium and later Germany.[38]

Finance companies appeared in England and, especially, Scotland in the form of investment trusts, whose object was to spread risks over a number of investments and to use part of the surplus as a redemption fund to reim-

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37 Jones, *British Multinational Banking*.

38 See D. Landes, 'Vieille banque et banque nouvelle : la révolution bancaire du XIXe siècle', *Revue d'histoire moderne et contemporaine*, 3 (1956). In addition, there is a vast literature on the development of commercial and investment banking in the various European countries, including monographs on individual firms.

burse the initial capital. Unlike investment banks, they did not seek to exert any form of control over the companies in which they invested.[39] Other types of finance companies, more closely linked to specific industries or firms, later developed in Continental Europe and America.[40]

The picture is different for the twentieth century, with a clear shift towards the United States, especially after the Second World War.

There was no major innovation in the interwar years. New finance companies, the investment trusts and the holdings of public utilities, made their appearance in the United States and fuelled the speculative fever that gripped the country in the 1920s. They enjoyed tremendous growth and drew a lot of attention, but they were not really a financial innovation. As just noted above, investment trusts had been known for a long time in Britain and holdings belonged to the same family of finance companies. Their operating principles, however, had become different, actually far riskier[41] –John Kenneth Galbraith described them as 'the most notable piece of speculative architecture of the late twenties'.[42]

From the 1950s onwards, all major finance innovations –certificate of deposits, derivatives, securitisation, venture capital, private equity, hedge funds –originated in the United States. This is not the place to discuss the origins and development of each of these innovations. Some of their roots can be found in older banking and financial practices. But there is no doubt about the highly innovative character of these financial products, institutions, and markets. In the case of securitisation, for example, the innovation was not so much the conversion of debt into marketable securities, which had been going on for a long while, as the type of debt that was securitised and the financial products emerging from this conversion.

There was, however, one exception: the Euromarkets, possibly the most important financial innovation of the twentieth century, were a European innovation. The Eurodollars market was born in 1957 when London banks started to use dollars instead of pounds to finance third party trade –follow-

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39 Y. Cassis, 'The emergence of a new financial institution: investment trusts in Britain 1870–1939', in J.J. van Helten J.J. and Y. Cassis (eds.), *Capitalism in a Mature Economy. Financial Institutions, Capital exports and British Industry* (Aldershot, Elgar, 1990).

40 S. Paquier, 'Swiss holding companies from mid-nineteenth century to the early 1930s: the forerunners and subsequent waves of creation', *Financial History Review*, 8, 2 (2001).

41 J. Rutterford, 'Learning from One Another's Mistakes: Investment Trusts in the UK and the US, 1868-1940', *Financial History Review*, 16, 2 (2009).

42 J.K. Galbraith, *The Great Crash, 1929* (Boston, Houghton Mifflin, 1955).

ing a government's ban on the use of sterling instruments for such transactions.[43] And the first Eurobond was issued in 1963 by Siegmund Warburg, the head and founder of the City merchant bank S.G. Warburg & Co., on behalf of Autostrade Italiane, a subsidiary of the Italian state holding IRI.[44]

However, an important point to bear in mind is that, even though London bankers were the founders of the Euromarkets, American banks quickly dominated it. Their share of the Eurodollar market went from 17 per cent in 1958 to 54 per cent in 1969 − their maximum level.[45] In the Eurobond market, eight American banks ranked among the top 20 intermediaries between 1963 and 1972, as against only three British ones.[46]

The retreat of European banks from the forefront of financial innovation thus provides another, more qualitative indicator, of Europe's relative, and yet uneven, financial decline in the twentieth century.

Limited convergence and integration

So far, no distinction has been made between the financial history of Europe and the financial history of Britain, France, Germany, and occasionally smaller countries, such as Belgium, the Netherlands, or Switzerland. And not only has Britain been included in Europe, but it has been given a prominent place, commensurate to its position within European finance in the twentieth century. Each European country can be considered as a representative of the Old Continent, even though there is a bias towards the larger economies. But how much do these countries have in common as far as their financial architecture is concerned? Let us first consider the convergence and divergence between the various European financial systems, before turning our attention to their level of integration.

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43 C. Schenk, 'The Origins of the Eurodollar Market in London, 1955–1963', *Explorations in Economic History*, 35 (1998).

44 K. Burke, 'Witness seminar on the Origins and Early Development of the Eurobond Market', *Contemporary European History*, 1, 1 (1992), 65-87; N. Ferguson, *High Financier. The Lives and Time of Siegmund Warburg* (London, Allen Lane, 2010).

45 S. Battilossi, 'Banking with Multinationals: British Clearing Banks and the Euromarkets' Challenge, 1958–1976', in S. Battilossi and Y. Cassis (eds.), *European Banks and the American Challenge Competition and Cooperation in International Banking Under Bretton Woods* (Oxford, Oxford University Press, 2002).

46 Kerr, *A history of the Eurobond market.*

Convergence

The rise of the big banks in the late nineteenth and early twentieth century was a common feature of all European countries, but it concealed the existence of very different national banking systems.

Each system had its idiosyncrasies, but a major difference was between countries where universal banks were predominant (Germany, Austria, Switzerland, Belgium, Italy); and those where the two activities were separate, though not necessarily by law, (Britain, France, Sweden, the Netherlands).[47]

Despite these differences, one cannot really talk of bank-oriented and market-oriented financial systems in the early twentieth century. Admittedly, the capital market was more developed in England than in continental Europe, but it should not be forgotten that the majority of issues floated in the City of London were on behalf of foreign governments and corporations.[48] As a matter of fact, in all European countries, self-investment remained the main source of finance for industrial companies, complemented by bank loans ant the issue of bonds and equity.[49]

Another difference concerns the degree of concentration of the banking systems. The contrast is particularly striking between Britain and Germany. On the eve of the First World War, the five largest London banks controlled 43 per cent of the deposits in England and Wales, as against only 12 per cent for the nine big Berlin banks. This difference is reflected in the number of banks: 55 commercial banks in England, as against 352 in Germany; but also 202 savings banks in England, as against 3,300 in Germany.[50] Most continental European countries were closer to the German than to the English model, especially as far as savings banks and other types of cooperative banks are concerned.

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47 Kindleberger, *A Financial History of Western Europe*; Y. Cassis (ed.), *Finance and Financiers in European History 1880-1960* (Cambridge, Cambridge University Press, 1992); G. Westerhuis, 'Commercial Banking: Changing Interaction between Banks, Markets, Industry, and State', in Cassis, Schenk, Grossman (eds.), *Oxford Handbook of Banking and Financial History*, 110-32.

48 Y. Cassis, *La City de Londres, 1870-1914* (Paris, Belin, 1987); J.J. van Helten and Y. Cassis (eds.), *Capitalism in a Mature Economy. Financial Institutions, Capital exports and British Industry* (Aldershot, Elgar, 1990).

49 J. Edwards and S. Ogilvie, 'Universal Banks and German Industrialization: a reappraisal', *Economic History Review*, 49, 3 (1996); M. Collins, 'English Banks Development within a European Context, 1870-1939', *Economic History Review*, 51, 1 (1998); C. Fohlin, 'The Balancing Act of German Universal Banks and English Deposit Banks, 1880-1913', *Business History*, 43, 2 (2001).

50 F. Capie, 'Commercial Banking in Britain Between the Wars' and G. Hardach, 'Banking in Germany, 1918–1939', both in Feinstein (ed.), *Banking, Currency, and Finance in Europe Between the Wars.*

The growth of joint stock companies led to the development of stock exchanges in all Europe's financial capitals, each with its specific set of rules.[51] The London Stock Exchange separated the function of brokers and jobbers, the latter being market makers.[52] The Paris *Bourse* was divided between an official market, the *Parquet*, where the number of *agents de change*, appointed by the government, was limited by law; and an unofficial one, the *Coulisse*.[53] The Berlin *Börse* was dominated by the big banks, and restrictions were imposed on speculative transactions in the securities of large industrial companies –which moved to Amsterdam and London.[54] In terms of size, the London Stock Exchange was by far the largest, about twice as large as Paris or Berlin, or for that matter New York.

The interwar years were at once a period of continuity and change. The First World War did not lead to any change in the banking practices of the big banks. The 'Big Five' British clearing banks had become giant banks, but they still mainly restricted their activities to deposit banking.[55] German Banks, for their part, remained universal banks. However, they now relied on American short-term capital to fund their long-term lending to industrial enterprises –which was a source of financial instability.[56]

The financial crises of the Great Depression led to more divergence. First, despite the global nature of the Great Depression, the banking crises of the 1930s did not affect all countries simultaneously and in the same degree.[57] The United Kingdom did not experience a financial crisis, even though the Bank of England had to support the worst affected merchant banks.[58] The crisis of September 1931, when Britain left the gold standard, was a currency crisis, not a banking crisis, and actually alleviated rather than

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51 R. C. Michie, *The Global Securities Market: A History* (Oxford, Oxford University Press, 2006).
52 R. C. Michie, *The London Stock Exchange. A History* (Oxford, Oxford University Press, 1999).
53 P.-C. Hautcoeur and A. Riva, 'The Paris financial market in the nineteenth century: complementarities and competition in microstructures", *Economic History Review*, 65, 4 (2012).
54 H. Pohl (Hg.), Deutsche Börsengeschichte (Frankfurt am Main, 1992).
55 All clearing banks significantly increased their accepting business and, especially Barclays, developed a network of branches overseas. See A.R. Holmes and E. Green, *Midland. 150 years of banking business* (London, Batsford, 1986); M. Ackrill and L. Hannah, *Barclays. The Business of Banking 1690-1996* (Cambridge, Cambridge University Press, 2001).
56 H. James, The German Slump. Politics and Economics 1924–1936 (Oxford, Oxford University Press, 1986). T. Balderston, 'German Banking between the Wars: The Crisis of the Credit Banks', *Business History Review*, 65, 3 (1991); Hardach, 'German Banking'.
57 Y. Cassis, *Crises and Opportunities. The Shaping of Modern Finance* (Oxford, Oxford University Press, 2011).
58 O. Accominotti, 'London Merchant Banks, the Central European Panic and the Sterling Crisis of 1931', *The Journal of Economic History*, 72, 1 (2012).

aggravated the economic crisis.[59] In France, the crisis was protracted, but never very severe, at any rate in terms of banks' failures, though a massive credit crunch hit the country during the 1930s.[60] In Italy, the troubles of the two large universal banks in 1930 and 1931 were kept secret until after the government's intervention. The most severe financial crises took place first in Austria, with the collapse of the Credit Anstalt in May 1931, and then, especially, in Germany in July 1931, when the country's major banks stood on the edge of the abyss and government intervention just managed to recover the situation.[61]

So there were several financial crises in Europe in the early 1930s, but it is hard to talk of a European financial crisis in the same way as one would talk of the American financial crisis –even though the latter consisted of four successive banking crises breaking out between 1930 and 1933 and affecting different regions at different times, until reaching a national climax in early 1933.[62] There was a common underlying cause to all the financial crises in Europe, and that was the Great Depression, but different economic, political and geopolitical factors led to different outcomes.

Policy responses to the crisis were equally different. Regulatory measures were introduced in all countries, with the exception of Britain. However, their effects remained limited –in contrast to the United States, where the Glass-Stegall Act, separating commercial banking from investment banking, fundamentally changed the American Banking system.[63]

In Europe, only two countries abolished universal banking: Belgium and Italy. Despite having experienced the most severe banking crisis of the

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59 Kunz D.B., *The battle for Britain's gold standard in 1931* (London, Croom Helm, 1987); B. Eichengreen, *Golden Fetters. The Gold Standard and the Great Depression 1919–1939* (Oxford, Oxford University Press, 1995); P. Williamson, *National Crisis and National Government: British Politics, the Economy and Empire, 1926–1932* (Cambridge, Cambridge University Press, 1992).

60 P. Baubeau, E. Monnet, A. Riva, and S. Ungaro, 'Fight-to-safety and the credit crunch: a new history of the banking crises in France during the Great Depression', *Economic History Review*, 74, 1 (2021)

61 Harold James, 'The Causes of the German Banking Crisis of 1931', *Economic History Review*, 37, 1 (1984); Theo Balderston, 'The Banks and the Gold Standard in the German Financial Crisis of 1931', *Financial History Review*, 1, 1 (1994); Isabel Schnabel, 'The German Twin Crisis of 1931', *Journal of Economic History*, 64, 3 (2004), and the discussion with Thomas Ferguson and Peter Temin in the same issue.

62 E. Wicker, *The Banking Panics of the Great Depression* (Cambridge, Cambridge University Press, 1996).

63 E. White, 'Banking and Finance in the Twentieth Century', in S.L. Engerman and L.E. Gallman (eds.), *The Cambridge Economic History of the United States,* iii, *The Twentieth Century* (Cambridge, Cambridge University Press, 2000). 743-802.

Great Depression, Germany did not do so. The banking law of December 1934, enacted under the Nazis, attributed the crisis to individual failings rather than to any shortcomings of the system.[64] In the same way, Austria and Switzerland, which was not spared a severe banking crisis, did not ban universal banking.[65] In France, the Vichy government introduced a law which made a clear separation between an investment bank and a deposit bank.[66] However, such a separation had *de facto* been in existence since the late 19th century. It was known as the '*doctrine Henri Germain*' from the name of the founder and at the time chairman of the Crédit lyonnais who, following the 1882 banking crisis, laid down the unwritten rule for commercial banks of maintaining liquid assets, in particular by avoiding industrial financing, an activity to be left to another type of banks, the *banques d'affaires*, the French version of investment banks.[67]

European convergence did occur in one area: the Great Depression marked the end of a half-a-century of uninterrupted growth of the big banks. In all European countries, including the United Kingdom, they lost ground to savings banks, cooperative banks, and other public and semi-public institutions.

State intervention and regulations were the dominant feature of the 'Golden Age', but with variations from country to country. The State, for example, was highly interventionist in France and Italy, less so in Germany. The forms of this intervention also varied. The large commercial banks were nationalised in countries such as France or Austria, if they had not already been nationalised before the war, as in Italy.[68] But their activities, in particular the distribution of credit, could be controlled by the government without nationalisation, as in Britain.[69]

Financial markets were also subjected to a number of restrictions.[70] On the London Stock Exchange, for example, options, considered highly speculative, were only reintroduced in May 1958, after an interruption of

64 James, *The German Slump*.
65 H. Bänziger, 'Vom Sparerschutz zum Gläubigerschutz – Die Entstehung des Bankengestezes im Jahre 1934', in Eidgenössischen Bankenkommission (Hg.), *50 Jahre eidgenössische Bankenaufsicht* (Zurich, Shulthess Polygraphischer Verlag, 1985), 3-81.
66 C. Andrieu, *Les banques sous l'occupation. Paradoxes de l'histoire d'une profession* (Paris, Presses de la fondation nationale des sciences politique, 1990).
67 M. Lescure, 'La banque et le financement de l'économie : Introduction', in Desjardins et al. (dir.), *Le Crédit lyonnais.*
68 A. Prost (dir.), *Les nationalisation d'après-guerre en Europe occidentale*, special issue *Le movement social*, 134, 1986.
69 M. Collins, *Money and banking in the UK: a history* (London, Routledge, 1988).
70 Michie, *The Global Securities Market.*

nineteen years.[71] In France the Paris Bourse entered a 'long depression' that lasted until the 1980s.[72]

In most European countries, Switzerland being a notable exception, foreign exchanges were also controlled. Free convertibility on current account was re-established in 1958, but controls on capital transfers took longer to be lifted, from the 1960s to the 1980s, again depending on countries –early in Germany, late in France.

From the mid-1970s, the pendulum swung back towards deregulation and globalisation.[73] This led to greater convergence –essentially at three levels. First, in all European countries, the rise of the big banks, which had stalled during the Great Depression and the early post-war years, regained momentum, at the expense of the cooperative and semi-public institutions –though some were still amongst their country's leading banks at the end of the twentieth century: Crédit agricole in France, a few *Landesbanken* in Germany (WestLB, Bayerische Landesbank, Bayerische Vereinsbank), or Rabobank in the Netherlands.

Second, the growth of the big banks led to a greater level of banking concentration. By the late 1980s, in all major European countries, the five largest banks held more than 50 per cent of total assets, with the exception of Britain, Germany, and Spain. A low level of concentration had always been a feature of German banking, where savings banks and public institutions retained a significant market share. In Britain, by contrast, the 'Big Five' controlled some 80 per cent of commercial banks' deposits, but only 33 per cent if one takes into account the assets of all financial intermediaries, including overseas banks and, especially, foreign banks, whose presence had massively increased since the 1960s. The case is less clear for Spain, though the savings banks remained a significant component of the financial system.[74]

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71 Michie, *The London Stock Exchange*.

72 O. Feiertag, 'The International Opening-up of the Paris Bourse: Overdraft-Economy Curbs and Market Dynamics', in Cassis and Bussière (eds.), *London and Paris as International Financial Centres*.

73 A. Drach and Y. Cassis (eds.), *Financial Deregulation. A Historical Perspective* (Oxford, Oxford University Press, 2021).

74 Y. Cassis, 'Introduction: A Century of Consolidation in European Banking – General Trends', in M. Pohl, T. Tortella and H. Van der Wee (eds.), *A Century of Banking Consolidation in Europe. The History and Archives of Mergers and Acquisitions* (Aldershot, Ashgate, 2001).

The third converging level was the adoption of a new model of transnational banking by the world's leading banks, including European banks, as a result of technological advances and increasing interactions between banks and financial markets. By the turn of the twenty-first century, global finance was dominated by the world's leading universal banks –Citigroup, J.P. Morgan Chase, Bank of America, HSBC, RBS, Barclays, Deutsche Bank, BNP Paribas, UBS, Credit Suisse, ABN AMRO, Santander, and a few others. They had a worldwide presence; they were engaged in all types of banking and financial activities, including retail banking, investment banking, trading, wealth management, and alternative investments such as hedge funds and private equity; and they had internalised their international activities, and were thus able to draw resources from one place and exploit them in another.[75]

Despite this European, and indeed international convergence, differences persisted between financial systems. Within Europe, the bank-oriented model prevailing in Continental Europe has been contrasted with the market-oriented system prevailing in the United Kingdom. And yet the differences can be overstated. The United Kingdom seemed more like a bank-oriented *and* a market-oriented system, with a similar level of bank loans as in the Eurozone, but a larger equity market, and a smaller bond market[76] –thus probably closer to Continental Europe than the United States.

Integration

Limited convergence went hand in hand with limited integration. By the late twentieth century, retail banking remained nationally oriented, despite the advent of the European Community in 1958 and, especially from the 1970s, efforts to reduce barriers towards cross-border banking activity – because of different regulation, taxation, customers' protection, as well as grater trust in national institutions.

There were, however, a few step forwards, leading to greater cooperation. The first was the formation in the 1960s of 'banking clubs'. Clubs were co-

[75] C. Kobrak, 'From Multinational to Transnational Banking', in Cassis, Grossman and Schenk (eds.), *The Oxford Handbook of banking and Financial History*, 163-90.

[76] F. Allen and E. Carletti, 'The Roles of Banks in Financial Systems', in A.N. Berger, P. Molyneux and J.O.S. Wilson (eds.), *The Oxford Handbook of Banking* (Oxford, Oxford University Press, 2010), 38-40.

alitions among big commercial banks, in which each preserved its full and complete independence. Their primary goal was to enable their members to offer their services in different European countries without having to be represented there directly. Their cooperation took many different forms, including creating banking consortia to intervene on the Euromarkets. Four main clubs brought together most of the big European banks, with in principle no more than one bank per country: ABECOR, EBIC, Europartners and Inter Alpha. However, these cooperative structures collapsed at the beginning of the 1980s –for a number of reasons, including the abandonment of the Werner plan for European monetary union; and conflicts of interest among members, and their desire to establish their own network of branches in other countries and to be represented directly in the main international financial centres.[77]

The second step started in the late twentieth and early twenty-first century with the building by the largest European banks of networks of branches in other European countries, mainly through the acquisition of smaller banks in the target country. BNP Paribas, for example, expanded in Italy, Belgium, and Poland; Deutsche Bank, in Spain, Italy, and Greece. However, they never gained a dominant position outside their own country. In 2006, foreign banks' subsidiaries and branches only held 17.9 per cent of total assets in the euro area[78] –though it was higher in Eastern Europe. A proper integration would require a few cross-border mergers between Europe's leading banks, something that has not happened so far.

The situation was different in wholesale banking. These activities are mainly concentrated in major financial centres, and the most striking point here has been their growing concentration in the City of London. London never really became the financial capital of Europe, in the way that New York is the financial capital of the United States and Tokyo the financial capital of Japan. Still, in 2000, London represented 55 per cent of the total EU output of wholesale financial services, with concerns over their possible dispersion.[79]

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77 D. Ross, 'European Banking Clubs in the 1960s: A Flawed Strategy', *Business and Economic History*, 27 (1998); D. Ross, 'Clubs and Consortia: European Banking Groups as Strategic Alliances', in Battilossi and Cassis (eds.), *European Banks and the American Challenge*.

78 J. Goddard, P. Molyneux and J.O.S. Wilson, 'Banking in the European Union', in Berger, Molyneux and Wilson (eds.), *The Oxford Handbook of Banking*, 833.

79 Roberts and Kynaston, *City State*, 189.

Conclusion

To conclude: this broad survey of Europe's financial history in the twentieth century in terms of 'relative decline' and 'limited convergence and integration' was not meant to be any kind of assessment of the 'performance' of the Old Continent's financial industry. Rather, it reflects Europe's changing overall position, both externally and internally, in the twentieth century. This raises an important question: to what extent can banks and financial markets alter the economic environment in which they are working, and to what extent are they straightjacketed by this environment? It obviously works both way, and the latter has been emphasised in this lecture.

However, there is no doubt that finance has had an impact on the European economy in the twentieth century. The issue has given rise to intense debates in the last third of the twentieth century mainly centred around the role of banks in industrial development and more generally economic growth, starting with Alexander Gerschenkron in the 1950s and Rondo Cameron in the 1960s.[80]

Economic historians have approached the question from a comparative perspective, and the comparison attracting most attention has been between Britain and to a lesser extent France on the one hand, and Germany on the other hand.[81] There was an important scholarly literature considering that British and French banks had not sufficiently supported their domestic industry.[82] However, empirical research on British and German banks has shown that differences were far less pronounced than usually assumed, with the former being found to have played a greater role, and the latter a smaller one, in their respective country's industrial develop-

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80 A. Gerschenkron, *Economic Backwardness in Historical Perspective* (Cambridge, Mass., Harvard University Press, 1962); R. Camron et al., *Banking in the Early Stages of Industrialisation* (Oxford, Oxford University Press, 1967).

81 For an assessment of the debate, see Y. Cassis, 'Introduction', in I. Kharaba and P. Mioche (dir.), *Banques et industries. Histoire d'une relation timorée du XIX*e *siècle à nos jours* (Dijon, Editions Universitaires de Dijon, 2013), 7-13.

82 G. Ingham, *Capitalism Divided? The City and Industry in British Social Development* (London, Macmillan, 1984); S. Newton and D. Porter, *Modernization Frustrated: The Politics of Industrial Decline in Britain since 1900* (London, Unwin Hyman, 1988); M.H. Best and J. Humphries, "The City and Industrial Decline", in B. Elbaum and W. Lazonick (eds.), *The Decline of the British Economy* (Oxford, Oxford University Press, 1986); W.P. Kennedy, *Industrial Structure, Capital Markets and the Origins of British Industrial Decline* (Cambridge, Cambridge University Press, 1987).

ment.[83] The European-wide consensus reached by economic historians is that banks did not 'fail' industry and contributed positively to their country's economic development.[84]

Interestingly, economists reached broader though similar results a decade or so later, with Ross Levine, for example, considering that finance mattered in economic development, but that the good working of financial institutions and markets was more important than whether the financial system was market-oriented or bank-oriented.[85]

The terms of the debate have changed in the beginning of the twenty-first century, with criticisms addressed to 'financialisation', in other words, and to put it simply, an unbridled rise of finance in all aspects of advanced Western economies and societies –though the issue has been taken up by sociologists rather than economic historians and economists.[86] The jury is still out on the relationships between finance and the real economy in the early twenty-first century. But the Global Financial Crisis of 2008, or the North Atlantic Crisis, as it has sometimes and more accurately been called, has clearly shown there was something wrong in the financial sphere.

Does the Crisis mark a turning point in Europe's financial history? Historians have the advantage of working with the benefit of hindsight, so it will be for the Sarton medallist of 2039 to answer this question. However, Europe's relative decline is unlikely to be halted, so Europe's position in global finance would then gain to be approached from a different perspective. Convergence and integration, on the other hand, might well

83 P.L. Cottrell, *Industrial Finance 1830-1914. The Finance and Organization of English Manufacturing Industry* (London, Methuen, 1980); D. Ross, 'Commercial Banks in a Market-oriented Financial System: Britain between the wars', *Economic History Review*, 49, 1 (1996); F. Capie and M. Collins, 'Banks, Industry and Finance, 1880-1914', *Business History*, 41, 1 (1999); M. Collins and M. Baker, *Commercial Banks and Industrial Finance in England and Wales*, 1860-1913 (Oxford, Oxford University Press, 2003). V. Wellhöner, *Großbanken und Großindustrie im Kaiserreich* (Göttingen, Vandenhoeck & Ruprecht, 1989); J. Edwards and K. Fischer, *Banks, finance and investment in Germany* (Cambridge, Cambridge University Press, 1994); C. Fohlin, *Finance Capitalism and Germany's Rise to Industrial Power: Corporate Finance, Governance, and Performance from the 1840s to the Present* (Cambridge, Cambridge University Press, 2007). M. Lescure, *PME et croissance économique : l'expérience française des années 1920* (Paris, Economica, 1996).

84 F. Capie and M. Collins, *Have the Banks Failed British Industry?* (London, Institute of Economic Affairs, 1992). A. Plessis, 'Les banques, le crédit et l'économie', in M. Lévy-Leboyer et J.C. Casanova (dir.), *Entre l'Etat et le marché : L'Economie française des années 1880 à nos jours* (Paris, Gallimard, 1991.

85 R. Levine, 'Financial development and Economic Growth: Views and Agenda', *Journal of Economic Literature*, 35 (1997); R. Levine, 'Bank-Based or Market-Based Financial Systems: Which is Better?' *Journal of Financial Intermediation*, 11 (2002).

86 G.R. Krippner, *Capitalizing on Crisis. The Political Origins of the Rise of Finance* (Cambridge, Mass., Harvard University Press, 2011).

increase, but at the cost of a smaller European Union, deprived of its strongest financial actor –though that might be reversed in the course of the twenty-first century.

Laudatio Raymond Van Holder

Norbert Lameire

It is a great honour being invited to introduce this Sarton lecture by my colleague and good friend, Prof emeritus Raymond Vanholder at the presentation of the Sarton Medal.

Raymond, Camille, Marie, José Vanholder, although being born in Ghent on october 17th, 1949 is in heart and soul, a true "Drongenaar". I do not know how many inhabitans of Drongen village realise that, next to their world star Kevin De Bruyne, currently world- famous as soccer player, and becoming very rich in Manchester, another world star, this time in the field of nephrology, resides on their territory. Despite his long academic career, however, Raymond Vanholder has become much less wealthy….

After his secondary education in the Greek-Latin humanities at the Ghent Saint Barbara college, Raymond studied medicine at our Alma Mater and graduated with distinction as a doctor of medicine, surgery and obstetrics in 1974.

Raymond is married to Dr Kathleen Eeckhaut, who herself had an active career as an occupational physician and the family has 2 charming and brilliant children: Kaatje, who works as a general practitioner in a group practice in Ghent, and Pieter, who is master in law, and currently works as Executive Director of the NGO European AIDS Treatment Group.

It is impossible to summarize the academic, professional and scientific career of colleague Vanholder within this limited time span of a few minutes.

Table 1 is an attempt to summarize his academic career.

- He was research assistant in the Laboratory for Renal physiology, dir. Prof. Dr. P.P. LAMBERT, Queen Elisabeth Foundation, Brussels, from 1.10.1978 till 30.9.1979 supported by a stipend of the National Fund of Scientific Medical Research.
- Research assistant Division of Nephrology, Department of Medicine, University Hospital Ghent (Dir: prof Dr. S. Ringoir), from October, 1sth 1980.
- Senior lecturer of then University of Ghent : 1sth October 1991.
- Member of the faculty INFA (International Faculty for Artificial Organs), Bologna, from 1sth October 1993.
- Professor of Medicine from 1997.
- Senior professor, 2000.
- Head of the Division of Nephrology, University Hospital, Gent, between 1/10/2005 till 31/10/ 2014.
- Emeritus Prof of Medicine: 2014.

Even before he was "professorable", Raymond was already noticed in the lay press and as a young scientist he put the fire to the then minister of education, Willy Claes. This was at the invitation of the newspaper De Standaard, where young talents were given the opportunity to interview prominent politicians.

I do not know which pertinent questions Willy Claes had to answer, but from his "panic" look at the photo published in the newspaper of that day, it can be deduced that Willy would rather have preferred to be at the Labour Party office at that moment.

Table 2 summarizes up to July 2021, the number of the most prominent papers of Raymond Vanholder from his academic CV.

Update July 2021	pages	#
A. INTERNATIONAL JOURNALS	9-75	824
B. BELGIAN JOURNALS	76-78	45
C. PROCEEDINGS	78-81	40
D. ABSTRACTS & LETTERS TO THE EDITOR	82-125	542
E. CHAPTERS IN BOOKS /THESIS /EDIT. BOARD-PEER REVIEWER, ELECTRONIC PUBLICATIONS.	126-135	48

From that list of publications can be deduced that in addition to the 824 A publications, with a total impact factor of 5597, including 9 articles in journals such as The Lancet, there are 32 publications in journals with an impact factor > 32 and 146 with impact factor > 10. The Hirsch Index of Raymond Vanholder is 88 (WOS) and 115 according to Google Scholar.

In total he also delivered 1977 invited lectures (at home and abroad) and promoted or was external examiner in 90 PhD dissertations.

Looking at this impressive number of publications and lectures, one wonders when he has done this all and, that probably, he had time for nothing else but his work.

It goes without saying that this is partly true, but he still made time to actively participate in sometimes “less academic” post-congressional activities.

During his long career Prof Vanholder has received a number of important international prices and awards which are summarized in Table 3.

- Robert W. Schrier Award for the Kaunas-Gent ISN Renal Sister Center Program. Issued by the International Society of Nephrology, April 2007.
- Richard Yu Endorsement Award. Hong Kong. China. 2013.
- International Distinguished Medal of the National Kidney Foundation (USA). 2015.
- Award for outstanding contributions to ERA-EDTA (European Renal Association – European Renal Dialysis and Transplant Association). 2016.
- Bywaters Award for sustained excellence in research on Acute Kidney Injury of the International Society of Nephrology (ISN). 2019.
- Award from the Balkan Association of Nephrology, Dialysis, Transplantation and Artificial Organs (BANTAO). 2019

It should also be mentioned that Raymond has actively participated in sports (including marathon running) and that he is an excellent kitchen chef, what is highly appreciated by all who have been able to enjoy these talents.

- He is a world authority on Research and Characterization of uremic toxins
- Partly due to the numerous interventions of the Renal Disaster Relief Task Force, which were carried out from the Ghent nephrology division, in collaboration with Doctors Without Borders during major renal disasters occurring during earthquakes and hurricanes, he is also an authority in the field of acute kidney injury in crush syndrome

- As President of the European Dialysis and Transplant Association/European Renal Association, he has made a major contribution to the scientific development of European nephrology
- To this day, he still plays an important role as chairperson of the European Kidney Health Association, an organisation aimed at raising awareness of the problems surrounding kidney disease at the level of European political authorities.

Last but not least, Prof Vanholder is also an excellent speaker and didactic teacher what, I am sure, will be greatly appreciated during his Sarton lecture on the topic “The history of dialysis” based upon his recent research in the latter field.

The history of dialysis

Raymond Vanholder

1. Normal and dysfunctional kidneys

The human body functions like a factory. It consumes energy sources (in this case oxygen and calory sources like glucose and lipids) to generate end products (like this text), but this process produces also waste. These waste products must be removed from the body to avoid their accumulation, which is a potential cause of biological dysfunction and thus toxic impact. Together with the liver and the lungs, the kidneys are the most important body organs for removal of waste products. The normal kidneys eliminate about 170L of blood water per day through the pores of the membrane of the glomeruli, which are the microscopic structures in the kidneys where filtration of the plasma water takes place. Subsequently, almost all water and also other molecules which are essential are reabsorbed, with ultimately only 2L being excreted via the urine. Waste products are, however, mostly not reabsorbed and appear full grade in normal urine what causes its yellow color. Typically, with severe kidney dysfunction, if there is still urine production, this yellow color largely disappears, illustrative of the fact that waste is no more fully present and thus not efficiently removed.

When kidney function degrades, either acutely (acute kidney injury – AKI, in popular terms, kidney blockade) or chronically (chronic kidney disease – CKD), the metabolites that normally are evacuated or degraded via the kidneys, remain in the body and become accumulated (retention). In this way, kidney dysfunction acts like an intoxication, but an intoxication from inside, not outside, the body. This condition is known as uremia which is a term derived from urea, the retention product with the highest concentration[1,2]. Next to urea, however, many other solutes accumulate in the body (uremic retention products) which modify biological functions of the body, and result in a gradual development of an endogenous intoxication named uremic toxicity[3]. The responsible molecules are termed uremic toxins and the totality of functional disturbances is called the “uremic syndrome”, resulting in a condition affecting virtually every organ system[4]. This deterioration of other organs than the kidneys may in its turn also impact kidney functioning, e.g. in the cardio-renal syndrome[5], whereby kidney dysfunction can affect the whole cardio-vascular system, whereas these cardio-vascular lesions in turn deteriorate kidney function, generating a sort of vicious circle.

The most important functional changes affecting outcomes in kidney disease are damage to the heart and the vessels, cognitive (brain) dysfunction with as most extreme situation uremic coma, and susceptibility to infectious disease. Chronic kidney disease and the uremic syndrome can thus be seen as systemic conditions[4]. In addition, however, advanced kidney disease also has a great impact on quality of life, inducing all sorts of cumbersome, be it not fatal, complaints, such as itching or fatigue, and affecting social and family life[6].

The number of patients known with kidney disease is growing due to many factors[6] (especially ageing and obesity with propensity to diabetes, one of the main causes of kidney disease) and chronic kidney disease is projected to become by 2040 the fifth cause of death worldwide[7] (see below).

The insight that damage to the kidneys could emanate in specific clinical problems had been growing from the 18th century on and was described in depth in the 19th century by the British physician Richard Bright[8,9]. Bright, working at Guy’s Hospital in London, UK, alongside Addison and Hodgkin, mainly proposed an anatomical concept of kidney disease, focusing on the structural alterations of diseased kidneys. He considered the kidneys as central organ for the disease as a whole. In the same period, the chemist and pharmacist Dumas and the physician Prévost in Geneva, Switzerland, studied the retention process that occurred in dogs whose kidneys had been removed, and demonstrated that this intervention caused an increase in urea concentration[8,9]. The German pathologist and physician von Frerichs who was active a bit later than Bright and worked in the Charité Hospital in Berlin as successor of Johann Schönlein, adhered to a more humoral view, stressing that the changes in the kidneys also affected organs at a distance and in fact caused dysfunction of the entire body[8,9]. This vision is more conform to our modern vision of kidney disease, which is characterized by the retention of many uremic toxins that affect a myriad of body functions[1,10,11]. Frerichs, who had among his students and assistants Langerhans, Quincke and Ebstein, was also the first scientist to use the term “uremia’ for the retention process.

Until approximately eighty years ago, advanced kidney disease (kidney failure) was a fatal condition, whereby patients who did not die from co-morbidities like cardio-vascular disease gradually developed cognitive dysfunction ending with coma and ultimately death. However, due to the development of one of the first artificial organs, this inevitable fatal end could be prevented or more exactly, postponed. This novel method was named dialysis. In order to allow a correct understanding of the text that follows, it should be stressed that there are currently two major types of dialysis strategies (figure 1). One option, which is the most frequently used, is named hemodialysis and removes blood from the circulation, pumps this blood through a manufactured plastic device with a semipermeable membrane composed of polymers with pores, where at the other side of the membrane purified water with appropriate electrolyte content is pumped. The solutes that are accumulated in the blood due to kidney failure are then eliminated to this dialysate. This process is controlled by the rules of osmotic shift following the presence of a concentration gradient, whereby due the physical laws solutes automatically shift from higher to lower concentration; the cleansed blood is then returned to the patient. In the second option, peritoneal dialysis, water containing electrolytes is instilled in the peritoneal cavity and intoxicating solutes that are retained in the body are shifted from blood to peritoneal cavity, again along the concentration gradient. When the peritoneal fluid is saturated with intoxicants, it is removed from the peritoneal cavity and replaced by instilling a new volume of clean dialysis water. Hemodialysis is usually intermittent and necessitates a machine to pump blood and dialysis water in and out of the filter. This intermittency makes that the patient is free of dialysis for most of the time (usually, hemodialysis is exerted for 4-5, exceptionally more, hours, after which the patient is free of dialysis for at lest 43 hours). However, this intermittency is also demanding, as patients with advanced kidney disease do not only accumulate uremic toxins but also water, because often no or not enough urine is produced by the sick kidneys. As all this excess fluid needs to be removed in a short period of time, it causes lots of stress to the heart and makes patients often feel bad for a variable period after the dialysis procedure. On the other hand, peritoneal dialysis is either continuous (24 hours per day), or semi-continuous (multiple exchanges over night with dry abdomen or one exchange during the day). The continuous procedure does not necessitate the support of a machine, but the semi-continuous option is partially automated.

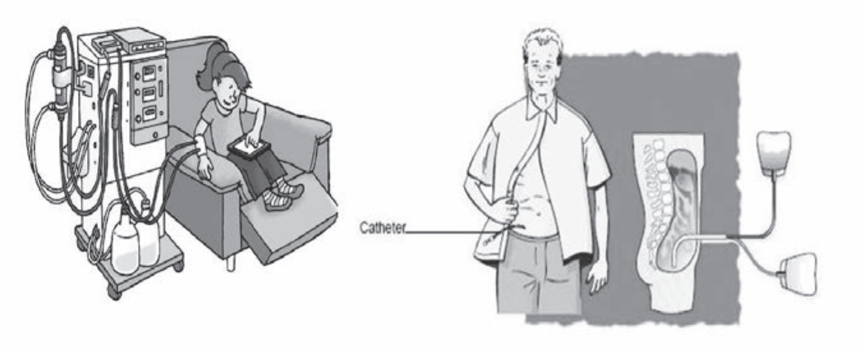

Figure 1: The two basic types of dialysis: left, hemodialysis – the patient is coupled to a machine through which blood and dialysis water are pumped; right, peritoneal dialysis - water is brought into the peritoneal cavity; in both strategies blood is cleansed from waste products according to the ruling concentration gradient by a shift from high to low concentration, thus out of the blood stream.

Currently, the majority of dialysis is exerted in-center. Only 15 % is occurring at home, mostly as peritoneal dialysis but also for a small fraction as home hemodialysis[12].

Hemodialysis was one of the first if not the very first artificial organ therapy that allowed to prevent (or at least delay) death from a potentially fatal type of organ failure. The intention of the present publication is to describe how this strategy came into being and how it evolved over time. As dialysis remains as of today one of the main interventions to remove uremic toxins in the most advanced stages of kidney disease, the knowledge about dialysis techniques and that on uremia are strongly intertwined. Therefore, in this publication, we will sporadically also discuss uremic toxins, where appropriate. We will also consider the current situation and problems imposed by dialysis treatment today, and, based on this, we will propose some thoughts on what the future evolution might be, thereby taking into account the ingenious spirit of the pioneers who made the invention of dialysis possible.

2. History of dialysis

Techniques to cleanse the body from presumed deleterious components (mostly without success), such as bloodletting, go back to antiquity and were applied for a broad array of diseases (figure 2).

Figure 2: image of a bloodletting procedure on an antique vase.

Bloodletting could be considered as a sort of primitive precursor of dialysis, as it removed blood that was presumed noxious to the patient from the blood stream and hence the body. The main difference with dialysis is that the blood was discarded after its withdrawal, instead of being cleansed and then returned to the patient. Bloodletting remained in use for medical purposes until far in the 19th ad even the early 20th century, directly or indirectly, by the use of leeches.

Similarly, ascites puncture aimed at the removal of excess fluid that is accumulated in the peritoneal cavity (e.g. due to heart or liver failure) was used already in the 17th century with the intention of the removed fluid to be discarded. Also this treatment could be seen as a precursor of peritoneal dialysis, now with as main difference to peritoneal dialysis that the removed fluid was not replaced by clean water to promote diffusion. In 1744, the Reverend Stephen Hales, a British physiologist, chemist and inventor, who is however best known for his work as a botanist, described a method to instill fluid (in this case wine) into the peritoneal cavity[13]. Although meant to treat ascites and not kidney failure, the concept was the same as of what in later days would become peritoneal dialysis.

Enemas were used to purge the body via the removal of intestinal content. Again, the idea was not that absurd, taking into account that the intestine is a source of many of the toxic compounds that are accumulated in the body during kidney failure[14]. Even in modern times, enemas have been used to treat kidney failure if dialysis possibilities were lacking, like by the Vietcong in the Vietnam war. More recently, the role of the intestine in uremic toxin generation was highlighted[14,15], resulting in the development of therapies to impact this generation, e.g. by oral administration of xenobiotics[16,17].

The first scientist to make fundamental steps into the direction of dialysis was the Scottish chemist Thomas Graham, who worked in Edinburgh, Glasgow and London. Graham developed in the midst of the 19th century a procedure (figure 3) to separate molecules from each other[8].

Originally aimed at measuring osmotic pressure (osmometer), the principle of the procedure he invented was as follows: if a liquid containing molecules is introduced in a device containing a membrane with pores large enough to allow these molecules to pass, while that device is surrounded by a fluid with a lower concentration of these molecules, then a shift occurs from the higher to the lower concentration. This physical process was named diffusion and the procedure itself dialysis. The same procedure is still used in laboratories worldwide to purify complex solutions from impurities or to separate molecules based on their size. Diffusion is still nowadays also one of the most important basic physical processes driving clinical dialysis (figure 4). Graham is thus correctly considered as (one of) the fathers of dialysis and he certainly was the first ever to describe the basic principles.

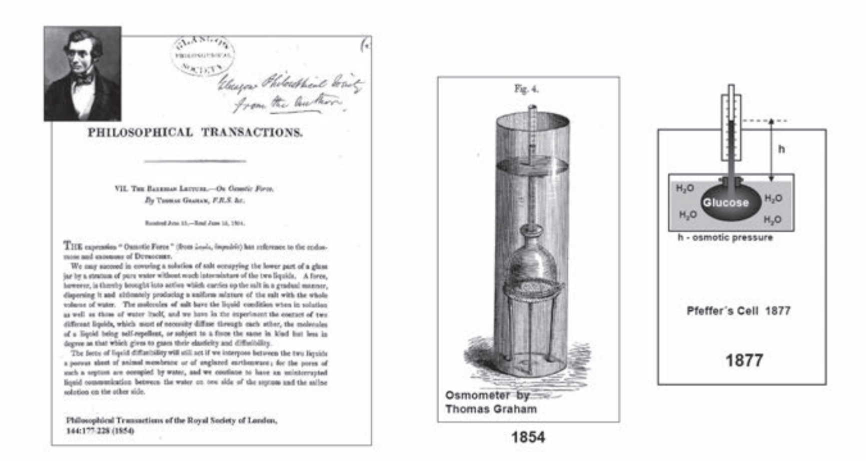

Figure 3: Role of Thomas Graham in the development of dialysis. Left: one of Graham's texts. Middle: one of his inventions, the osmometer. Right: principle of dialysis – glucose shifts through a semipermeable membrane to surrounding water without glucose (details in the text and figure 4).

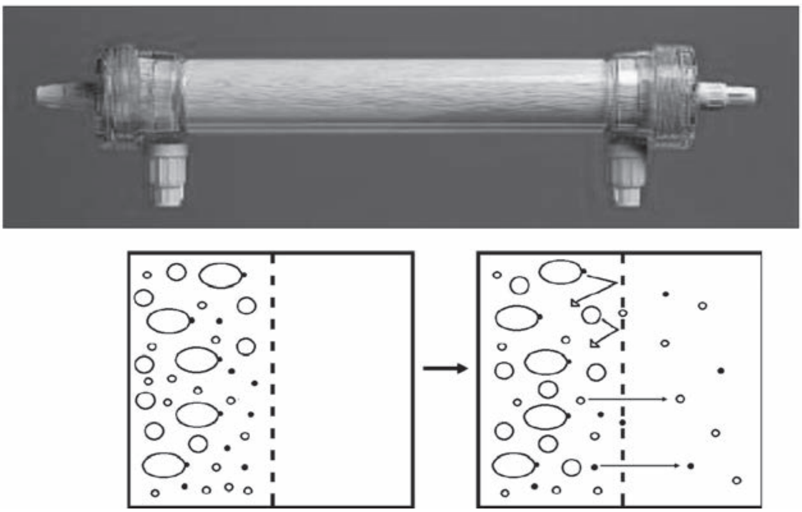

Figure 4: Diffusion as the basic process of dialysis. Above: a current hemodialyzer. Below left: situation at start – a complex solution is contained at one side of the membrane, with a solution without those elements at the other. Below right: due to diffusion, the smaller elements (e.g. uremic toxins) are shifted through the membrane, whereas the larger ones (e.g. blood cells) are not.

The first scientists to apply this principle for blood purification in an *in vivo* procedure were Abel, Turner and Rowntree in Baltimore, USA, at Johns Hopkins School of Medicine. Abel and coworkers demonstrated in 1913 the removal of salicylate from the blood of dogs by a procedure that they named vivififfusion[8,18]. In this way the development of dialysis shifted from purely European to a mixed European-American effort. John Abel was born in Cleveland, Ohio, US, but received most of his training in Europe, mainly at the universities of Strasbourg and Leipzig, where he worked together with Kussmaul and von Recklinghausen, before returning to the US. He was also instrumental in the isolation of epinephrine and insulin. Rowntree was a Canadian physiologist who worked essentially in kidney research and among other things also developed a kidney function test (Rowntree test). It is more difficult to find information about Turner. After his stay at Johns Hopkins, Turner became professor at Indianapolis University and at one point in time nominated John Abel (without success) for the Nobel Prize in medicine, but not for his work on dialysis but for his endocrinological research.

Of note, the procedure Abel and coworkers developed had as primary intention to purify and replace plasma, which was conceptually closer to the current therapeutic option named plasma exchange than to hemodialysis[8,18]. Also worth mentioning, a similar concept had been used with the same intention almost simultaneously by the Russian scientist Vadim Yurevich[19], who worked at the Medical Surgical Academy in St Petersburg. This accomplishment is often ignored in Western medical literature when reflecting on the history of dialysis, possibly because he published his observations only in the Russian medical literature.

The credit for the first human application of the hemodialysis principle should be attributed to Georg Haas who performed this procedure in Giessen, Germany[20]. Haas had during the first World War been upset by his own powerlessness to save the life of soldiers suffering from acute kidney injury, that was the consequence either of the crush syndrome after having been entrapped under debris due to bombing, or from infections affecting the kidneys. After a number of experiments in animals, he managed in 1924 using a primitive dialysis device to make disappear severe uremic symptoms such as vomiting, headache, insomnia and restlessness in a patient. The improvement lasted for 6 days after the treatment after which they recurred. Haas performed a further number of dialyses in the period 1924-1928 which usually lasted only for a short period, i.e. about 15 minutes, as they were technically hampered by the unreliability of the anticoagulant (hirudin) and the dialysis membrane (collodion)[21,22]. Hirudin was difficult to obtain, non-standardized and toxic, and collodion was difficult to make, fragile and of unpredictable permeability. After stopping the procedure, his patients slumbered again into a coma and, if their kidney function did not recover, ultimately died. Haas discontinued his experiments because of these shortcomings and the lack of support by the German scientific community, an evolution that frustrated him deeply. The authoritative internist Franz Volhard, who made during his career important contributions to nephrology, stated that dialysis was useless and even dangerous. For many years the pioneering accomplishments of Haas were forgotten, and, once hemodialysis gained momentum in the fifties of previous century (see below), Haas had personally to remind the German medical community about the key role he had historically played in the development of this strategy[23].

It took quite some time towards developments that offered the possibility to overcome the obstacles Haas had encountered. William Thalhimer who worked in the Public Health Research Institute in his native New York started a few years before the beginning of the second World War to use semipermeable membranes composed of cellulose. He also started applying a more reliable anticoagulant, heparin. This move was inspired by the experience of Thalhimer with heparin for blood transfusion. He combined both novelties for dialyzing uremic dogs. These two solutions would become cornerstones in the evolution to modern dialysis[22]. The later pioneers of modern dialysis, among them the Dutch physician Willem (Pim) Kolff (see below), were aware of Thalhimer's work and cited it in their publications[22].

The first series of dialysis treatments that can be considered as the start of modern life-saving hemodialysis was accomplished in 1942 by the Dutch physician Willem Kolff in Kampen, the Netherlands[24]. Like Haas, Kolff too had been frustrated by the death of patients with acute kidney injury whereby he was powerless as no therapeutic possibilities were available. He followed a similar approach as Thalhimer by using cellulose membranes and heparin, but, in contrast to Thalhimer, he applied those for *in vivo* dialysis in men[24]. He made his machine from all sort of material he could collect because it was available even during the war years and used sausage skin (which during the second World War was composed of artificial material made of cellulose), and parts of automobiles and laundry machines (figure 5).

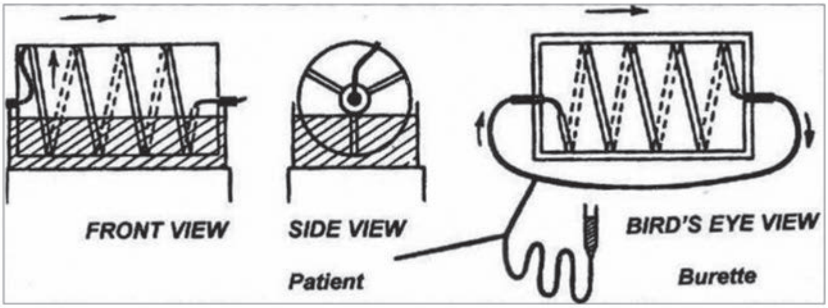

Figure 5: Schematic of the first dialysis machine developed by Willem Kolff.

The first sixteen patients treated by Kolff died despite dialysis treatment. However, in 1945, it became possible for him to save for the first time the life of a patient with acute kidney injury and uremic coma by dialyzing her as described in Kolff's thesis assertion, entitled "De kunstmatife nier" (figure 6).

Figure 6: Title page of Kolff's thesis

Kolff's first surviving patient was Sofia Schafstadt, who suffered from a sepsis due to cholecystitis. Schafstadt, who was thus the seventeenth patient dialyzed by Kolff regained consciousness during dialysis and her kidney function recovered afterwards.

Schafstadt had collaborated with the Germans and was detained in a post-war prison camp when she developed her cholecystitis. It is a bit ironic that Kolff, who had been the whole war in conflict with the Germans and who took part in the Dutch resistance movement now was saving the life of someone who had collaborated with the Germans. The tale goes that the first thing Schafstadt said when she woke up from her coma was that she would divorce from her husband (who had been in the resistance), something she actually really did when she recovered. Probably this first success was a reason for Kolff to continue with dialysis but as he could not find sufficient support in the Netherlands for his work, he subsequently migrated to Cleveland/Ohio, USA and later to Salt Lake City, Utah. In addition, Kolff continued to work for the rest of his life on several other artificial organ projects, amongst them artificial heart, artificial eye, heart-lung machine and wearable artificial kidney. Kolff continued this work until his death in 2009 at the age of almost 98.

Shortly after Kolff, also being aware of Thalhimer's innovations, Gordon Murray (Toronto, Canada) and Nils Alwall (Lund, Sweden) separately developed dialysis machines of which the design already more closely resembled what is used nowadays[22].

Originally, dialysis remained essentially limited to acute kidney injury, because of the need to directly puncture both the femoral artery and the femoral vein to obtain access to the vascular bed for blood purification. This was possible then only for a limited number of consecutive sessions. Because of this disadvantage, primitive dialysis therapy remained more suited for acute kidney injury, as this was the only cause of kidney disease with a reasonable chance for recovery of kidney function after a few days, after which dialysis was not further needed. With the chronic type of kidney disease, such recovery was unlikely, and thus long-term dialysis was impossible to provide, because of shortage of access possibilities.

The start of the use of hemodialysis on a larger scale occurred during the Korean war (1950-1953). Paul Teschan, a military doctor from Nashville, Tennessee, US, and major in the US army, who would later perform pioneering work in the search for the uremic toxins causing cognitive dysfunction in kidney disease[25], treated several wounded soldiers with acute kidney injury by dialysis. Previous to this evolution, war-related mortality of acute kidney injury was 80-90 %, but in Korea, this figure decreased to 53 %[26]. This resulted in a more extended application of dialysis than before, when it had been reserved for single isolated cases This was essentially made possible by the involvement of industry, allowing the upscaling of the production process of dialysis material[27]. The first company to become involved was Travenol that later on would become Baxter Healthcare.

At this stage, the difficulty to gain repeated access to the vascular bed, excluding almost all patients with chronic kidney disease, remained the main bottleneck. Introduction in 1960 by Belding Scribner in collaboration with Wayne Quinton of the arterio-venous shunt (the Quinton-Scribner shunt) (figure 7) largely enhanced the possibilities for repeated connection of the dialysis machine with the blood stream via an external plastic cannula connecting the arterial and the venous circulatory systems[28]. Belding Scribner (Seattle, Washington, US) was a pioneer of hemodialysis and one of the first to apply dialysis on a larger scale. His invention also made it possible to make a bridge to kidney transplantation, which also started to be exerted more extensively and with success in virtually the same period[29]. The more extensive use of hemodialysis, however, created a new problem of too many candidate patients for too little available positions for treatment, so that triage became necessary. This generated an ethical challenge which was taken care of in Seattle by an anonymous committee that next to medical professionals also contained a housewife and a priest. The philosophical reflections that were originated by this difficult selection problem are often considered as the starting point of bioethics.

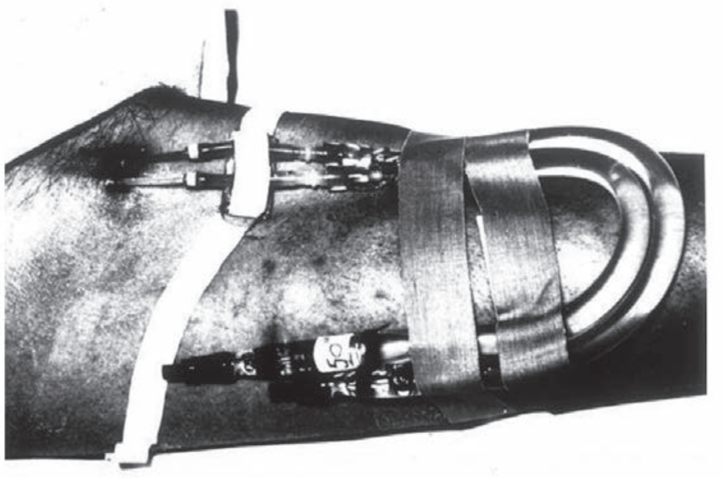

Figure 7: Photograph of an arterio-venous (Quinton-Scribner) shunt. A plastic tubing connects an arm artery and vein.

This difficult choice was soon thereafter solved by creating broader availability of hemodialysis in higher income countries[2] but shortage of dialysis possibilities, either economically or materially, remains even nowadays a problem in many countries, especially those with lower economic resources[30]. As more patients were treated and cost of dialysis was high, not much later another problem arose, that of reimbursement and health economy, and for long, expenditure for hemodialysis was considered as maximal allowable reimbursement cost in proportion to gain in outcome and quality of life.

Already a few years after the introduction of the Scribner shunt, Cimino and coworkers described the surgical creation of an arterio-venous fistula, i.e. the direct surgical connection of an artery of the arm to a vein, as an alternative option for access for dialysis. This reduced the Quinton-Scribner shunt to a note in history of hemodialysis and the Cimino-Brescia fistula became standard procedure[31]. James Cimino is best known for his work in palliative care but he also developed the fistula that would carry his and Michael Brescia's name in 1966, during his time at the dialysis unit of the Bronx Veterans Administration Medical Center in New York, US. Michael Brescia is to our knowledge still alive and devoted most of his career to palliative care and humanitarian action. As the Cimino-Brescia fistula option made use of endogenous vessel material to connect the arterial with the venous vascular bed, in stead of foreign (plastic) material in case of the shunt, the novel procedure was quickly adopted by the nephrological and vascular surgery community as it reduced the risk for clotting and infection, enabled easy access by needle puncture, and assured long-term availability[31]. In addition, the influx of arterial blood at high flow rates into the more flexible and expandible venous vascular bed allowed to develop high blood flows through the dialysis filter, in its turn enabling to remove enough toxic solutes from the body of the patient during a dialysis session of only a few (usually 4-5) hours and allowing for a long dialysis-free interval (intermittent hemodialysis).

As hemodialysis by definition also is necessitating the use of pumps, to bring the blood of the patient and the dialysis water to the filter and from there back to the patient or the drain, the history of pump development for medical purposes is also worth mentioning. Interestingly, one of the earliest medical pumps was a perfusion pump developed by Charles Lindbergh, the same as the first pilot to cross the Atlantic Ocean between New York and Paris with a nonstop flight. From historic perspective, Lindbergh is an interesting subject because of his many facets. Apart from the well known facts of his transatlantic flight and the kidnapping of his son, Charles Jr, Lindbergh also was engineer, inventor (he invented a watch for pilots that is still in use), advisor in rocket development, innovator of aviation (e.g. the initiator of polar fight routes) and author of books for one of which he won the Pulitzer price. Lindbergh also worked as a biomedical engineer and during the period when he stayed for a few years in France he collaborated with the Nobel Prize winner Alexis Carrell to develop in the years preceding World War II a prototype of a pump, to be used to perfuse whole organs. This concept has been considered to make future heart surgery and organ transplantation possible[32]. In a book summarizing his work with Carrel, Lindbergh also described a concept of artificial heart, probably inspired by the dismal fate of his sister in law who suffered from heart failure.

Lindbergh, however, also had his dark sides. He overtly sympathized with Nazism (although he later in his life revoked this), was on excellent terms with Hermann Göring, was a strong adept of eugenics and of the America first doctrine, and an anti-Semite. After his death, it appeared that next to his legal American wife, he also had three additional wives in Europe, and 7 extramarital children. Lindbergh figures as a protagonist in Philip Roth's novel, entitled "The plot against America", where Lindbergh fictively wins the 1940 US presidential elections against Franklin D Roosevelt after which he steers the US into the direction of fascism.

However, in hemodialysis machines roller pumps are used. In the same period as that of Lindbergh's work, a crucial step towards the clinical use of roller pumps, was played by the vascular surgeon Michael DeBakey (Houston, Texas, US), who transformed a roller pump used for blood transfusion into a device that could pump blood from one person to another[33]. Like for Thalhimer, his work in blood transfusion inspired him to make this advancement out of which several totally different areas profited, as this evolution would allow the later development of the heart-lung machine as well as of hemodialysis. DeBakey was a child of Lebanese immigrants, who was inspired to do medicine by the physicians who were clients at his father's drug store, whereas he learned sewing from his mother, which would be useful for his surgical career. His surgical innovations include carotid endarterectomy, coronary bypass operations, the use of Dacron grafts to replace vessels, ventricular assist devices, and as mentioned, artificial heart.

Peritoneal dialysis followed a similar evolution and development as hemodialysis. After a number of unsuccessful attempts like the one by Hales (see above), Georg Ganter (Würzburg, Germany) introduced the concept of peritoneal dialysis in 1923 and several reports appeared between the two World Wars and after World War II of its therapeutic use, especially in patients with acute kidney injury[34]. Those attempts were often unsuccessful due to complications, essentially infections related to a failing protective barrier where the access catheter crossed the skin in the direction of the peritoneal cavity, so that bacteria could enter the peritoneum causing peritonitis (peritoneal infection and inflammation). As antibiotics were not yet in use during a large part of this period or were at the beginning of their development, this evolution often had deleterious consequences The problem of transcutaneous infection was ultimately solved in 1968 by the proposal of a sustainable access system by Tenckhoff and Schechter (Seattle, Washington, US)[35]. Henry Tenckhoff was of German origin (born in Bergisch Gladbach and student at the University of Cologn), and had moved to Seattle, Washington, US, in the early sixties of previous century. Tenckhoff's innovation in peritoneal dialysis was as simple as ingenious. He introduced subcutaneous felt cuffs around the catheter to create a barrier for the cutaneous bacteria, which enabled maintenance peritoneal dialysis treatment in chronic kidney disease for prolonged time periods with low infectious risk.

Whereas in the early days of dialysis, there was not enough infrastructure to treat all candidates, after the involvement of industry and the extension of reimbursement possibilities[2] a steady year-by-year growth in number of treated patients occurred. This is due in part to a progressive increase in the incidence of kidney failure due to a rise in its causes, but in addition, better treatment of comorbidities in the period before dialysis as well as on dialysis, make that better survival outcomes also do increase this number. Another further enhancement of this growth can be expected in the coming years as uptake of dialysis will increase in lower income countries[36].

3. The current situation

With one in seven Europeans suffering from chronic kidney disease, one in three (i.e. all chronic disease patients) being at risk, the ageing of the population, the pandemic of obesity and ensuing diabetes, and the increasing uptake in lower income countries, the group on kidney replacement therapy can only be expected to grow in the coming years[6]. Starting from a 16th place in the classification of most fatal diseases worldwide, chronic kidney disease rose in 2020 the 10th position[6] (number 8 in high income countries), and it is by 2040 projected to become the fifth cause of death worldwide[7], preceding all cancer types. Five year survival when starting dialysis is worse than survival after the diagnosis of cancer. For dialysis patients, life expectancy is halved for all age strata compared to healthy people of the same age. Annual societal cost for chronic kidney disease (including all stages, also chronic kidney disease not on dialysis, and transplantation) exceeds that of cancer and diabetes (table 1)[6].

Table 1: Total annual cost of cancer, diabetes and chronic kidney disease (CKD)

	CANCER - DIABETES		**CKD**	
Topic	Cost estimate[a]	Reference	Cost estimate[a]	References
TOTAL CANCER	**103.0**	Hofmarcher et al[37]		
TOTAL DIABETES	**138.8**	Williams at al[38]		
Dialysis reimbursement			23.1	van der Tol et al[39]
Indirect dialysis costs			7.5	Mohnen et al[40]
Total transplant cost			12.2	Kerr et al[41] Vanholder et al[42] ERA-EDTA registry[43]
CKD 3-5 no KRT			73.6	Kerr et al[41] Hill et al[44]
CKD 1-2 no KRT			33.9	Jommi et al[45]
GRAND TOTAL CKD			**150.3**	

This analysis does not include the cost of acute kidney injury which would further extend projected expenditure.

Considering the cost per patient, expenses for hemodialysis, especially in-center hemodialysis, is very high, and global cost amounts to at least 2 % of overall annual health expenditure[46] with a proportionally higher percentage of input for lower than for higher income countries[39,47]. Hence, as the number of patients on kidney replacement therapy will further rise in the coming years, even if cost per patient remains the same, cost for society will rise and will reach fairly soon dramatic levels if the direction towards which we are moving is not modified.

The global annual cost for the chronic kidney disease population not yet on dialysis is larger than that for the patients on dialysis, but this is the consequence of their sheer number, as the quantity of patients with chronic kidney disease not on dialysis is at least 20 times larger than that of patients on dialysis. One of the reasons why the population on kidney replacement therapy is so small is the high mortality of chronic kidney disease, mainly due to cardiovascular events, before the patients reach the degree of kidney dysfunction necessitating replacement therapy.

Apart from the impact of kidney disease and its treatment on outcomes, quality of life and expenditure, kidney replacement therapy, and especially dialysis, is also imposing an important ecologic burden[48-50]. As uremic toxins are removed from the blood stream by a diffusion process against dialysate, water consumption is enormous, and one single hemodialysis session consumes up to 180 liters of water to end up in the drain. For a hemodialysis unit with 30 positions, yearly water consumption easily amounts to more than one million of liters and there are thousands of hemodialysis units around the world. The production of material and delivery of treatment also necessitates using substantial amounts of energy which results in equivalent greenhouse gas emission. Dialysis also necessitates the use of plastic material, that usually is intended for single use, and then discarded, which results in lots of waste. The delivery process involves transport of material, and for in-center hemodialysis, also of patients. Although data for peritoneal dialysis are less well known, it is assumed that also this option carries a substantial ecologic burden, due to the quantity of plastic needed for the bags containing dialysis fluid, of which the production consumes large amounts of water[51]. Solutions are needed for this huge ecologic problem, that is unknown to many.

The pioneers of dialysis treatment made use of several elements that came up over time to develop finally successful dialysis treatment. If the nephrological community wants to avoid a situation where appropriate therapy cannot be delivered to all valid candidates or that societal cost increases to exuberant dimensions, a spirit of out-of-the-box thinking will be needed, comparable to what drove Kolff and his colleagues, to ultimately come up with a strategy that is workable for the future. Yet the therapeutic arsenal for kidney disease has remained merely unmodified over de last 50 decades resulting in a virtual status quo. In spite of the uncredible human and socio-economic cost, investment in innovation for its treatment is far less substantial than that for other chronic diseases. Hence, the future way to go is to generate a shift of mind and to take a totally different direction. In the following section, we will propose a roadmap of how nephrology could evolve in future.

4. Future

4.1. Prevention

The best way to forestall the burden of a disease is to make that it does not happen or at least that it does not progress that far that it starts affecting outcomes and quality of life. Prevention is essential to make this come to pass. Primary prevention averts that a disease starts to be developed and essentially consists of healthy lifestyle, including exercising, abandoning smoking, appropriate and healthy food intake, and combating obesity and environmental pollution. Primary prevention is not expensive but necessitates planning, and efforts for education and organization. Unfortunately, governments invest less than 5 % of their healthcare budget in primary prevention.

Secondary prevention aims to decrease the risk of comorbidities and refrain the progression of kidney dysfunction, with the same lifestyle measures as for primary prevention, to which should be added specific medications, if available. Unfortunately, there has been not much innovation over time in possibilities to manage progression of kidney diseases. After the introduction of the angiotensin converting enzyme inhibitors (ACEi) and the related angiotensin receptor blockers (ARB) in the mid-seventies of last century[52], we had to wait for the appearance of the sodium-glucose transporter inhibitors (SGLT-2 inhibitors) in the last decade to see appear a new player with a direct impact on kidney disease progression for a large group of patients[53].

4.2. Transplantation

The alternative kidney replacement therapy to dialysis is transplantation, offering a better survival and quality of life and imposing a ten times lower societal cost than dialysis. However, only 44 % of European patients on kidney replacement therapies lives with a functioning kidney transplant and there are important differences in transplantation uptake among European countries[12]. Thus, kidney transplantation is underexploited in many European countries. Several policy actions to promote transplantation have ben suggested, but now need to be implemented[54].

4.3. Rethinking the concept of hemodialysis

The general concept of hemodialysis has not changed since its development almost 80 years ago by Willem Kolff, in contrast to many other technological fields, such as telephony or telecommunication where massive steps were made over the last decades to enable better performance and/or miniaturization. Here also, we thus need in the coming years a shift of mind guided by out-of-the-box thinking.

One of the ways to go is to develop more compact systems that are more easy to transport and that allow more easily home hemodialysis treatment and flexible scheduling, so that dialysis can be performed wherever and whenever a patient prefers (e.g. in a hotel, at work). This might include portable dialysis systems[2] that will be more easy to handle and better transportable between places than the current home hemodialysis possibilities, which are too much an adaptation of the available in-center hemodialysis options. Facilitating home treatment may improve quality of life and societal cost, and protect against future infectious threats, taking int account the outcome advantages observed in some countries in home dialysis patients during the COVID-19 pandemic[55]. Such a portable system might also be an intermediate step towards wearable dialysis. It may also be a way to diminish cost which is the main obstacle for uptake of medical technology in developing countries[56].

Finally, such a compact system, may also offer ecologic advantages, if dialysis water and possibly also other components of the dialysis set-up can be regenerated, whereas more easy application at home will reduce the ecologic disadvantages of patient transport.

4.4. Reducing uremic toxin accumulation by other means than dialysis or transplantation

It is an intriguing observation that the metabolic processes that lead to the generation of uremic toxins also may generate solutes that are favorable. As an example, tryptophan metabolism not only produces accepted uremic toxins such as indoxyl sulfate and the kynurenines but also beneficial compounds such as indole and indole-3-propionic acid. In addition, the main metabolic mechanism that is activated by all these solutes is the aryl hydrocarbon receptor pathway, which induces a number of deleterious effects such as inflammation or thrombosis but is also essential for detoxification and healthy ageing. One unsolved question is whether dialysis, which is an undiscerning removal system, does eliminate beneficial compounds together with the toxic ones, which would be undesirable.

Recently, there is a raising interest in other mechanisms to forestall uremic toxin concentration to rise. Many of the uremic toxins are generated by the intestinal microbiome, and interventions to modulate this element are currently studied. Administration of probiotics, prebiotics or synbiotics may modify the intestinal microbiome or its function resulting in a decrease of toxin concentration[17].

Another essential mechanism in uremic toxin removal is kidney function *per se*. Thus, any mechanism to slow down kidney function deterioration will also benefit uremic toxin concentration. It is very well possible that impacting intestinal microbiota and kidney function deterioration is more favorable for the maintenance or restoration of the balance between beneficial and toxic intestinal metabolites than dialysis, but this hypothesis needs to be assessed.

5. Conclusion

Kidney disease is more frequent and invalidating than often assumed. In addition, it shortens lifespan by about 50 % for all age classes and costs more to societies than any other chronic disease. Yet, we have experienced a therapeutic status quo over the last decades.

Dialysis was introduced as a life-saving or at least life-prolonging option close to 80 years ago. We can learn from the processes that played a role for this therapy to come to pass, to make modifications in the current therapeutic concept possible. The development of hemodialysis necessitated inventiveness of several people who stubbornly pursued to solve a seemingly unresolvable problem, herewith influencing and inspiring each other.

Today we live a pivotal moment as we are in need of the same pioneering spirit to solve the increasing pressure on the health care and health economic systems and on the environment. If we want to preserve our ideal that all valid candidates would receive the appropriate treatment for a reasonable societal cost, it will be necessary to reconsider our current therapeutic model to find more ecologic and less expensive solutions. Unfortunately, innovation has virtually stagnated since a number of decades. Maybe, the availability of dialysis as a relatively successful artificial organ, as compared to other fatal chronic diseases, unfortunately had a paralyzing effect and more or less precluded the search for other solutions that would intervene earlier in the patient course. The time has come, like with the invention of hemodialysis, to drastically change our therapeutic model of kidney disease, with more prevention, transplantation, home dialysis and sustainable and green therapeutic options.

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Laudatio Aart de Kruif

Ann Van Soom

Aart de Kruif is a veterinarian, but one that takes great interest in history and science. After the defense of his doctoral thesis at the faculty in Utrecht, he started working in veterinary practice, working mainly as a bovine herd health practitioner in Someren, the Netherlands. From 1987 onwards, he held a position as full professor at the faculty of Veterinary Medicine in Ghent, and became the chair of the department of Reproduction, Obstetrics and Herd Health. Aart possessed a natural aptitude for clinical teaching : the students appreciated his no-nonsense and applied lectures very much and he was able to blow a fresh wind through the faculty, leading to the start-up of a new series of postgraduate education programmes.The faculty soon recognized his organizational capacities or capabilities since he was elected as dean and remained that for many years. He also served as the Editor-in-Chief of the Flemish Veterinary Journal and became an active member and secretary of the Belgian Acadamia for Medicine, which he continued to be even after his retirement. He was one of the founding members of the European College for Animal Reproduction (ECAR), and he acknowledged the power of a united European Union.

Likewise, his interest in the early Erasmus programme took him on a train trip through Europe in 1989, to visit different universities like Hannover, Giessen and Copenhagen, in order to exchange experiences on international education at the university. Lifelong learning was one of the positions he supported fully. As one of his first PhD students, I accompanied him on this first trip through Europe and during the many long hours of the train journey, Professor de Kruif taught me many things about European history, some of which I had never heard of. I was informed on the Marshall plan, that was meant to help Europe to recover after World War II, which also included veterinary applications such as using specialized animal breeds for high yield production of milk (Holstein Friesian), meat (beef from Belgian Blue and porc from Piétrain) and eggs (Leghorn and Rhode Island Red chickens). He explained his interest in history as follows : by learning about the past, we avoid making the same mistakes in the future (which also typically applies to the Sarton philosophy).

This attitude was the basis for his optimistic view on the future. When some years later I discussed the problem of climate change with him, and the disasters it would bring upon our planet, he concluded that there was no reason for worries, since mankind would find a solution for every problem. He would give the example of the Great Manure crisis of 1894. This crisis serves as a metaphor for overcoming insurmountable problems with unexpected solutions and is explained on the website of the Mobility Museum in Utrecht[1] (text cited below):

> "Late 19th century cities like London and New York seemed to be 'drowning in horse manure'. In London, where the horse-carried *Hansom Cab* occupied the streets, 50.000 horses produced 570.000 kilograms of horse manure and thousands of litres of urine daily. Together with the corpses of dead horses, the urine and manure started to poison the city's inhabitants. In 1894 the Times predicted that "in 50 years, every street in London will be buried under nine feet of manure." The situation came to be known as the 'Great Manure Crisis of 1894'. Despite fierce debates among urban planners and various studies into the matter, no solution was found for years. This changed when Karl Benz, Gottlieb Daimler and others introduced motorized vehicles at a massive scale. By 1912 the crisis had been resolved. Electric trams and motorbuses had replaced horse-carried vehicles in the major cities. Ever since, the 'Great Manure Crisis of 1894' has served as a metaphor for overcoming insurmountable problems with unexpected solutions."

To further explain his positive attitude towards Science and History I will list three examples below that were indicative of his career, as a combination of his interest in history and science.

The first example is the Caesarean section. This is a surgical procedure mainly used in bovine obstetrics, which is meant to deliver large calves

1 https://www.uu.nl/en/research/urban-futures-studio/initiatives/mixed-classroom-techniques-of-futuring/mobility-museum-2050/the-great-manure-crisis

from cattle that cannot give birth in a natural way. In Belgium, it has historically become a routine procedure in the Belgian Blue breed, and is being performed in 90 % of cows of this breed, but has been much less accepted in other countries for reasons of animal welfare. Aart de Kruif did not condemn the procedure, which was by and large accepted in Belgium since the seventies, but instead refined the technique, and provided an educational movie (before Youtube even existed!) to instruct students and veterinarians how to perform a C-section. He supervised two PhD students on the topic, one including research on pelvic measurements to be used in selection of breeding cows, in order to produce more natural births in Belgian Blue cattle.

The second example is the epididymis. This is a storage organ for spermatozoa, located close to the testicle, in which freshly produced spermatozoa are being stored at 33° C for several days or weeks prior to ejaculation. This is quite interesting, since bull spermatozoa only live for a few hours when being kept at such a temperature after ejaculation. The routine way to store ejaculated spermatozoa is to cool them to 4°C or freeze them at -196°C, to lower or even stop their metabolism. De Kruif's suggestion for a novel diluter for fresh bull spermatozoa was based on this amazing property of the epididymis, and this idea led to a project suitable for 2 PhD students, and the development of a novel diluter for bovine spermatozoa in combination with a deep insemination devise, although it was never introduced into practice, since it was difficult to replace the very efficient and high performing frozen bull semen that is used in dairy cattle industry.

The third example was his general interest in the mechanisms of action of hormones, leading historically to different behaviour in men and women. He repeatedly told us he would write a book on this topic, and indeed, in 2012 his book was published entitled : "Typisch testosteron. De grote invloed van een hormoon op het gedrag van mannen én vrouwen". It gained critical acclaim in the Low Countries and Aart de Kruif was and still is repeatedly invited in Belgium and the Netherlands to give more lectures on this interesting topic.

Finally I would like to come back to the positive attitude of Aart de Kruif towards the world in crisis. Will we be able to feed 9 billion people by 2040? Some scientists blame agriculture and animal breeding for most of the problems associated with climate change and a high carbon footprint.

This is partially true, but for reducing our ecological footprint the following actions are most important, as listed on https://www.climateresponse.eu/you :

1. Have one fewer child (> 20 ton CO_2e/year)
2. Live a life without a car (> 2 ton CO_2e/year)
3. Avoid flying (1 ton CO_2e/year)
4. Buy green energy (> 1 ton CO_2e/year)
5. Eat plant based diet (> 0.5 ton CO_2e/year)

Vegetarian diet is only listed 5th, and let's not forgot that dairy cattle can turn inedible grass (from grasslands not suitable for general agriculture) into high protein and high quality dairy products like milk, which is in many aspects superior to its vegan counterparts. Only soy milk can be considered as a sustainable alternative to cow's milk, but is lower in calcium, phosphorus and vitamine D.

So hopefully there is still a future for the dairy cow and the managing veterinarian in this world in crisis. In the history of veterinary practice, excellent obstetrical skills have always been important, since the cow could only produce milk after the delivery of a calf. Surely professor de Kruif is a worthy recipient of the Sarton Medal, with his lecture entitled : "The history of veterinary obstetrics".

The history of veterinary obstetrics

Aart de Kruif

Summary

Helping animals who are in labor and / or whose parturition is not progressing is without doubt one of the oldest forms of veterinary medicine. For example, certain forms of birth assistance, such as the response to abnormal positions, were already described in ancient times. The use of simple tools, such as cords and drawbars, has also been known since "time gone by". Midwifery, both human and veterinary, was based during centuries – and perhaps millennia – on experience and simple craftsmanship, which had to settle for limited results. Certainly also because there was often nothing else than the application of heavy pulling force, where the risk was great that both the mother and the fetus would not survive.

It was not until the first half of the 19th century that significant progress was made. Subcutaneous fetotomy was developed and became more widespread. With this method of delivery, the calf could be reduced under the skin without undue risk to the dam and brought out in pieces. Only a hundred years later, another big step forward was made. Percutaneous fetotomy was developed. Because epidural anesthesia was put into practice at about the same time, the combination of both methods led to enormous advances in obstetrics in large animals. Between 1930 and 1960, percutaneous fetotomy was the preferred method of delivery in veterinary obstetrics. The results were good, the method was fast and effective and the technique was not too difficult to learn. Of course there was one major drawback: the fetus always had to be sacrificed.

A delivery method in which both the mother and the fetus could survive in good health had to wait for several decades. It was only when antibiotics became available for general practice that the time had come. The caesarean section made its appearance in the fifties and sixties of the last century, especially in cattle. This almost completely replaced the percutaneous fetotomy. In contrast to cattle, the caesarean section did not replace the fetotomy in the horse. The reasons for this are that foals often die quickly when birth problems occur, parturition in the mare can in most cases be terminated after a partial fetotomy and in mares complications frequently occur after a caesarean section.

In view of its minimal economic importance, nothing was ever published about obstetrics in small animals and exotic animals until well into the 19th century. The caesarean section also proved to be the solution for serious birth problems in these animal species.

Introduction

If you take a moment to think about what happens during a delivery, it is clear that from the very beginning, people have been involved with obstetrics, both in humans and animals (Drife, 2002, Todman, 2007).

Helping animals who are in labor and / or whose parturition is not progressing is without doubt one of the oldest forms of veterinary practice (Figure 1). For example, certain forms of birth assistance, such as the response to abnormal positions, were already described in ancient times.

The use of simple tools, such as cords and drawbars, has also been known from time immemorial. Obstetrics, both human and veterinary, was based on experience – and perhaps millennia – on experience and simple craftsmanship, which had to settle for limited results. Certainly also because there was often nothing else than applying heavy pull, where the risk was great that both the mother and the fetus would not survive (Grunert and Schäffer, 1993).

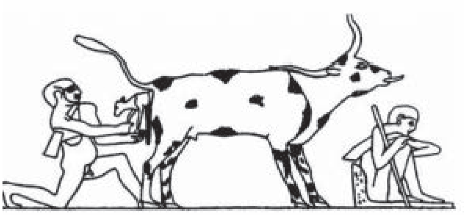

Figure 1: As this figure shows, help was already offered in ancient times at parturition.

Delivery methods

If a parturition proceeds normally, it is of course not necessary to intervene. If it is an abnormal parturition, there are various methods to end such a parturition. These are successively:

- increased pulling force
- reposition
- fetotomy
- caesarean section

Between a somewhat prolonged normal parturition caused by a fetus that is on the large side and the application of some pulling force, there is so little difference that it is easy to imagine that the application of pulling force at a parturition will have taken place for thousands of years. Even though this has not been described or published anywhere. The same can be seen with regard to moderate or heavy pulling power. In extreme cases, for example, forced extraction will have started very early in history. After all, nothing else existed! The calf, lamb or foal had to be removed. If it was not good, then bad, in other words: pull as hard as possible. Human pulling power (up to sixteen strong men, as has been described in ancient times), animal pulling power (horse) and all kinds of aids (cables, wheels, a winch) can be used for this. However, it will have been common in those early times that the fetus could not be born even with very high pulling force, and alternative methods will have been considered even then. This will also have happened if there was an abnormal position of the fetus. It is therefore obvious that simple repositions, such as a carpal position, were made very early in history. This will certainly have been the case with sheep and goats. The step to more complicated repositions is not so great, but requires more knowledge and experience. Yet the scarce ancient literature available on this subject shows that difficult repositions have been successfully completed for thousands of years. It is not certain whether very difficult repositions, such as in the mare, have taken place during that time. In the relevant literature there is only general terms, for example “if the fetus is in a wrong position, then straighten it” (Grunert and Schäffer, 1993)!

Even in those old times it will have happened regularly that the parturirion could not be terminated with either pulling force or reposition. In such a case, there was no other option than to cut the fetus in pieces. In human medicine, this could be done by means of a craniotomy. This method has also been in use for centuries, if not thousands of years. It was known early on that if the child’s head was reduced in size, the rest could usually be pulled out (Thiery and Goossens, 1993). In animals, fetotomie has already been performed in ancient times. However, the method is not well described anywhere, only in general terms, such as “if the fetus is much too large, cut it out in pieces”. It is easy to understand that this would not have been easy: there was little or no knowledge of anatomy and physiology, the method was only applied if the animal had already suffered a lot or was already half-dead and the necessary instruments were not yet available or were of poor quality.

It was not until the 18th century that some progress was made with the fetotomy method (Grunert and Schäffer, 1993). In the meantime, anatomical knowledge had increased significantly, the correct instruments became available and a few people had specialized in obstetrics (cow masters) (Figure 2). In other words, the time had come to successfully perform a fetotomy. In the 18th and 19th centuries it was always a subcutaneous fetotomy. With this method, the risk of damaging the uterus was minimal. After all, the relatively thick skin of the fetus acts as protection for the fragile and strongly tense uterine wall. With the help of a few finger knives, a spatula and a few hooks, the fetus is removed in pieces (Devriese, 2006). However, the subcutaneous method is not ideal: it is labor intensive and difficult to learn.

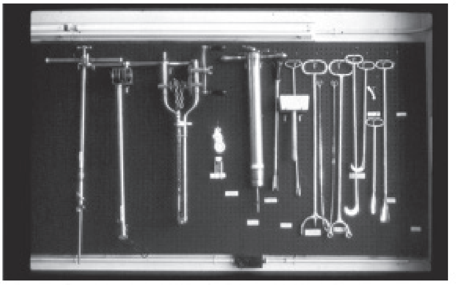

Figure 2. In the 19th century, the obstetric instruments consisted mainly of drills, spatulas and knives.

It was not until the early 20th century that a better method was developed: the percutaneous fetotomy. Even then the time had come to make this method a success (Van der Weijden and Rozendal, 1995). Epidural anesthesia became available, the tube fetotome was invented and was easy to handle, and the quality of the wire saws needed was greatly improved. In addition, this method was much faster than the subcutaneous fetotomy and was easier to learn. From 1920, the percutaneous fetotomy was the solution for animals that calved or foaled with too large a fetus. The mother animal almost always survived, but the fetus had to be sacrificed. This last point was the major drawback of the fetotomy. It would indeed be fantastic if both the mother and the fetus could survive. The answer was the caesarean section. Where does the word Caesarean come from? The word comes from Caesar, which in turn comes from Caedere = to cut. Basically, caesarean section means the same thing twice: sectioning. Julius Caesar probably got his name because one of his (distant) ancestors was born by caesarean section (Boley, 1991). The question, how can mother and child both survive, appears to be centuries or perhaps thousands of years old. Long before the beginning of our era, there were already summary reports about the removal of the child (dead or alive) from the belly of the mother (usually almost dying and she never survived). It was not until the 16th century that a successful caesarean section was first reported in which both mother and child survived (Boley, 1991; Sewell, 1993; Drive, 2002; Todman, 2007). Even in animals, caesarean sections were undoubtedly performed in the gray past, but there is no literature on this. Only in the 19th century did reports appear that a caesarean section was performed occasionally in animals, especially in cattle. Not much is known about the results. They were probably bad, otherwise it would have been mentioned. The time was not yet ripe (Van der Weijden and Rozendal, 1995). Only in the 20th century did things progress. The technique and the suture material improved, good anesthetics were developed, the knowledge of anatomy and physiology increased sharply and antibiotics came on the market. Around 1950 the time was fully ripe and the caesarean section started to rise steeply, especially in cattle, at the expense of percutaneous fetotomy (Vandeplassche, 1955 and 1964) (Figure 3). However, this was not without a struggle (de Kruif, 2007 and 2011)!

Fetotomy or caesarean section: which delivery method is preferable?

Vandeplassche and his colleagues conducted a lot of research in Ghent between 1950 and 1970 on the results of both fetotomy and caesarean section. They were very interested in this problem because there were so many birth problems in the heavy Belgian cattle breeds. They were therefore the first to publish on this subject. The central question was which delivery method was the best. For example, Vandeplassche wrote in 1955 “In Belgium, as in most countries, in addition to reposition and increased pulling, in a problematic parturition in the bovine, the tube fetotome according to Thygesen is mainly used. The results are very good for the dam, but the calves have to be sacrificed. Humans want to do better and better in all sectors of life, and some obstetricians have attempted caesarean sections to save the calf in addition to the dam. Using antiseptics, sulfonamides and antibiotics, the results have improved a lot compared to 20-30 years ago. Therefore, the caesarean section is increasingly used in cattle. This has the advantage that the operating technique is continuously improved. Some veterinarians do a lot of caesarean sections. These are usually veterinarians who have previously supported the caesarean section and who have opposed fetotomy. To justify their large number of caesarean sections, they propose numerous but unfortunately mostly theoretical and emotional arguments. Most other practitioners still do many fetotomies because of the good results for the dam. These veterinarians paid very little attention to caesarean section, both in large obstetric clinics and in practice. We think it is important, both in education and in practice, to know whether the caesarean section in cattle is really important or not. No theoretical discussion helps here. Only an objective comparison of both methods and of the results can give a correct answer. The fact remains that the owner's economic interests take precedence and that all other elements are secondary." (Vandeplassche et al., 1953).

Figure 3. Professor Marcel Vandeplassche (1914- 2001) can be considered the pioneer of the caesarean section in cattle.

Vandeplassche had already compared and analyzed the results of the fetotomy and caesarean section between 1949 and 1953. His final conclusion in 1953 was that the fetotomy undisputedly took the place of honor in a problematic parturition in cattle (Vandeplassche, 1955). He conducted more research between 1953 and 1955. His results are shown in Table 1. His final conclusion was that the results of a caesarean section were comparable to those of a fetotomy, but doubts were still felt as to whether a caesarean delivery was actually the best option in a complicated bovine parturition. For example, Vandeplassche (1955) wrote: "In the literature many authors still state that the main goal of a caesarean section in cattle is to have a live calf. This may be the case in exceptional cases. However, it is usually the case that the decision to perform a caesarean section is based on a possible economic reason: saving the dam. After all, in dairy cows, the value of the calf is on average only 10 % of that of the dam. In addition, in practice (probably if there is an operation at the farm) about 30 % of the calves, who were still alive at the time when it was decided to perform a caesarean section, during the operation or within 7 days after the surgery die. Especially the first hours after a caesarean section are dangerous for the calf. When an animal with a problematic parturition is brought to a clinic, many calves die en route and only 50 % of the calves remain alive" (Vandeplassche, 1955).

Table 1. The results obtained with a fetotomy and with a caesarean section in cattle (Vandeplassche et al., 1955).

The dam	**Caesarian section**	**Fetotomy**
The mortality rate in 207 cows with an oversized calf	2.4 %	6 %
Sufficient milk production	60 %	70 %
Retained placenta	38 %	13 %
Puerperal metritis	50 %	18 %
Normal fertility	64 %	82 %
The calf		
Mortality:		
-begin to end of the operation	4 %	100 %
-within 7 days after the operat.	26 %	
No solution		
Problematic parturition	1 %	2-5 %

Time went on and the caesarean section experience grew. The results improved. The mortality rate in the dams decreased to 2 % and that in the calves to 12 %. The number of complications during and after the operation also decreased. In addition, it turned out that fertility after caesarean section was less bad than originally thought. In 1959 Vandeplassche wrote (still very carefully): “The Caesarean section in cattle is technically fully developed, so that the results with a Caesarean section are at least as good as those with a fetotomy. Therefore, the veterinarian must decide together with the owner in each case separately on the basis of economic reasons which obstetric method he will use” (Debackere et al., 1959). Here the owner was mentioned for the first time. In the rapid advance of the caesarean section, it was not so much the vet, but the owner who played the leading role. The calves usually lived and were valuable. The farmers preferred the caesarean section. According to them, a caesarean section was absolutely necessary for a living calf. They rejected the fetotomy. But also the opinion of the vets evolved more and more in favor of the caesarean section. A caesarean section in dead and emphysematous calves was no longer considered an art flaw. In 1963 Vandeplassche wrote surprisingly: “In most textbooks and publications about obstetric care for cattle, the presence of an emphysematous calf is considered as a contraindication for caesarean section. Such animals should be delivered with a fetotomy or, if possible, undergo emergency slaughter. The methods and possibilities of obstetric care have evolved over time, and the indications and contraindications for caesarean section changes. Not accepting caesarean section in a cow with an emphysematous calf was usually the result of an a priori conviction that is not based on research data. Feelings, opinions and theoretical considerations are unreliable advisers. The results obtained by caesarean section should be compared with the results of emergency slaughter and fetotomy. Our results show that caesarean section is no longer contraindicated in a complicated parturition with an emphysematous calf" (Vandeplassche et al., 1963).

Over the course of 15 years the caesarean section had proven itself sufficiently and in 1968 Vandeplassche decided very convincingly: "The caesarean section has major advantages in bovine obstetrics. The economic results obtained with this method are unexpectedly very good".

But like any method, the caesarean section had a potential drawback. In the same year Vandeplassche wrote "The caesarean section can also be the cause of dystocia if simultaneously breeding methods do not intervene to prevent birth problems" (Vandeplassche et al., 1968). The typical example of this development has taken place precisely in Belgium: the selection aimed at the production of double muscled calves of the Belgian white-blue breed (BWB).

Vandeplassche has also conducted comparative studies in mares with dystocia. However, the indications for caesarean section in the horse are very limited: a transverse position, uterine torsion and an oversized foal. In contrast to cattle, the indication "an oversized foal" is rare. In addition, most foals die quickly if the birth process takes a little too long. A transverse position and a uterine torsion ad partum are also exceptions. The caesarean section in mares is cumbersome and a lot of help is needed. The costs are therefore high. In addition, the foal is usually stillborn and/or malformations are often found (Vandeplassche et al., 1962). The conclusion is that in most cases a fetotomy should be preferred. In 1977 Vandeplassche wrote "fetotomy remains a very important obstetrical method in the mare. We perform approximately 15 fetotomies against 1 caesarean section. In most cases it concerns a partial fetotomy" (Vandeplassche, 1977).

Conclusion

As early as ancient times, methods of delivery, such as increased pulling power and reposition, were used. Subcutaneous fetotomy was not applied until the 19th century. It was replaced around 1920 by percutaneous fetotomy.

In cows fetotomy has been almost completely displaced by the caesarean section. Percutaneous fetotomy is still preferred in the mare as a foal dies quickly and the risk of complications during and after a caesarean section is higher than in cows. Unfortunately, it has also been shown that the ease with which a caesarean section can be performed has led to a sharp increase in the frequency of dystocia, as is the case with the BWB cattle breed.

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