ACTA HISTORICA SCIENTIARUM NATURALIUM ET MEDICINALIUM

Vol. 42

Troels Kardel

STENO

LIFE · SCIENCE · PHILOSOPHY

with

Niels Stensen's Prooemium

or

Preface to a Demonstration in the Copenhagen Anatomical Theater in the Year 1673

and

Holger Jacobæus

Niels Stensen's Anatomical Demonstration no. XVI

and other texts translated from the Latin

Published by
The Danish National Library of Science and Medicine
Distributed by Munksgaard
Copenhagen 1994

Troels Kardel

STENO

LIFE · SCIENCE · PHILOSOPHY

Portrait ascribed to the period when Niels Stensen gave the *Prooemium* lecture in the Copenhagen Theatre 1673 as anatomist to King Christian V. Unknown artist. The Medical Historical Museum, Copenhagen University.

ACTA HISTORICA SCIENTIARUM NATURALIUM ET MEDICINALIUM

Vol. 42

Troels Kardel

STENO

LIFE · SCIENCE · PHILOSOPHY

with

Niels Stensen's Prooemium

or

Preface to a Demonstration in
the Copenhagen Anatomical Theater in the Year 1673

and

Holger Jacobæus

Niels Stensen's Anatomical Demonstration no. XVI

and other texts translated from the Latin
by Sister M. Emmanuel Collins, O.S.F., Ph.D. and
Paul Maquet, M.D., Doct. h.c.

Published by
The Danish National Library of Science and Medicine
Distributed by Munksgaard
Copenhagen 1994

ACTA HISTORICA SCIENTIARUM NATURALIUM ET MEDICINALIUM

Published by the Danish National Library of Science and Medicine
Copenhagen University Library
Mette Stockmarr, Chief Librarian

Distributed by Munksgaard
35 Nörre Sögade · DK-1016 Copenhagen K
Telefax +45 33 12 93 87

A series of monographs including editions of source material
for the history of science and medicine as well as monographs
on individual subjects and personalities
The issues are published in English

Manuscripts and enquiries concerning this series,
including collaboration and exchange, should be addressed to the editor:

Poul A. Christiansen, Advisory Librarian
49 Nørre Allé · DK-2200 Copenhagen N
Denmark
Telefax +45 31 39 85 33

ISSN 0065-1311
Vol. 42 ISBN 87-16-15100-3
Printed in Denmark by P.J.Schmidt A/S, Vojens

Contents

Niels Stensen 1638-1686

Translations

Preface and Acknowledgements

> The wish to know what escapes the senses stimulates reason, from the consideration of the different parts and from the comparison of the single individual parts, to search after the author of such wonders. *Prooemium p 123.*

When exploring three lesser known works, nos. 14, 22 and 28 of *Nicolai Stenonis Opera Philosophica* (*OPH*), for my publications *Steno on hydrocephalus* and *Steno on muscles*, I became aware of Stensen's investigative method of conjectures and comparisons to attempt falsification, so that *no disagreement* is established between what is observed and what is alleged. This led me to research similar applications of the scientific method described in this century by Karl R. Popper in Stensen's other scientific writings, a task which became possible for me, a non-Latinist biologist, through the cooperation with Sister M. Emmanuel Collins, O.S.F., Ph.D., Rochester, Minnesota and Paul Maquet, M.D. Doct.h.c. Aywaille, Belgium, and through help and advice by professor Leonard G. Wilson, Ph.D., University of Minnesota, Minneapolis.

My considerations on the life and scientific achievements of Niels Stensen are rendered together with his *Preface to an Anatomical Demonstration, OPH* 31, from Copenhagen 1673. Stensen's essay on science is followed by his student Holger Jacobæus's account of the anatomical demonstrations which followed the lecture, from *OPH* 36. Also in first English translation is, from the *Epistolæ*, (*E*), the *Addendum* no. 24, an unfinished essay of physiological psychology from Stensen's last years. A section from Henry Oldenburg's 1671 translation of Stensen's *De solido intra solidum, OPH* 27, is reprinted in chapter 3.3 to document the method of Stensen. Like professor Leonard G. Wilson, I hold this text to be an unrecognized first description of the compartmentalisation of the water space of living organisms.

In the presentation I have emphasized the contemporary and later recognition of Stensen's achievements. Occasional references have been made to the theological works (*OTH*) in which, however, I found no controversy with my main theses. Admittedly, this treatment is far from exhaustive as regards data available on Stensen. One cannot help feeling that he is inexhaustible. Heeding his words on the goal of scientific practice: "Now falsehoods to be overturned, now truths to be established, now dark areas to be lit, now unknown facts to be brought

forth",[1] it is meanwhile my hope that the selection made for this reconstruction will provide the reader with an impression of the mastery of one of the great scientists of humanity, Denmark's greatest in biology and geology.

I acknowledge with gratefulness all who helped me during this study, most of all Advisory Librarian Poul Aagaard Christiansen, the editor of the current series, Professor Leonard G. Wilson, Sr Emmanuel Collins and Dr Paul Maquet. A particular thank you to John Heng, M.A., Toronto, Canada, who helped editing my essay. In details concerning Stensen's biography, I received help from the Stensen-scholar Harriet M. Hansen, M.A. August Ziggelaar, S.J., D.Phil., kindly assisted with editing the Latin-English translations. Solveig Odland, M.A. kindly helped my study of Italian texts. I also wish to thank Professor Egill Snorrason, D.Med, D.Phil., who in 1985 asked me to contribute a paper on Stensen's myology in the memorial volume "Steno 1638-1686, A Re-consideration by Danish Scientists" and thereby launched my research in the history of science, and to Professor Paul Backer, M.D. for his interest in my study and support.

The colour plate of Niels Stensen's portrait was kindly provided by the Medical Historical Museum of Copenhagen University. I kindly acknowledge the permission to reproduce original material from the Royal Library, Copenhagen, and the Biblioteca Nazionale Centrale, Florence. The facsimile of the *Prooemium* and most of the remaining illustrations are reproduced from first editions in the Danish National Library of Science and Medicine.

My studies and this publication were made possible through the financial support from the Alfred Benzon Foundation. My sincere thanks are rendered to the President of the Foundation, Professor Jørn Hess Thaysen, D.Med., for his continued interest in the project.

Troels Kardel, D.Med.
General Practitioner
Copenhagen University
Dept. of General Practice

---

1. *Geological Papers (GP)*, pp 136-137.

1. Life and Science

1.1 Family and Childhood

Niels Stensen was born the second son of a goldsmith of the small street Klareboderne in Copenhagen in 1638, on New Year's Day according to the Julian calendar, on 11 January of the Gregorian calendar used in Denmark after 1700. From the family's workshop, several fine pieces of craftsmanship have been preserved to the present day.[2]

It was the second marriage for both Niels's father, Sten Pedersen, who came from a clerical family in the province of Scania (now Sweden), and his mother, Anne, of whom little is known. She must, however, have been a woman of vigour since she survived no less than four spouses. Niels[3] had an elder half-brother Johann who was a theologian, a half-sister Lisbet and a sister Anne. The family seems to have consisted of serious-minded, hardworking people of puritan habits, who were firmly established in their faith in God and King, and Niels's inclination toward puritanism was very likely formed in his childhood.

At the age of seven, Niels lost his father. His mother was able to continue the family business and remarried a few years later. Her son was encouraged to keep to the books, not the workshop. He became the ward of his brother-in-law, a clerk in the royal administration. During his childhood, Niels suffered from an illness lasting three years. He later recalled that, during that period, he learned to appreciate talking with older people on religious matters, and listening to their conversation instead of playing with other children.[4]

Stensen attended Our Lady's School, presently the Metropolitanskole. The headmaster was the gifted teacher of mathematics, Jørgen Eilertsen (1616-1686). Another teacher of science was Ole Borch (1626-1690), a distinguished Latinist who became ordinary university professor of philology and extraordinary professor of botany and chemistry in 1660. When well advanced in research, Niels showed respect for his early education by dedicating one of the scientific works on glands

---

2. Chalices from Sten Pedersen's workshop are found in Holmens Church, Copenhagen, in the New Jerusalem Church, Trankebar, India, and in the Parish Church of Valle, Norway, the latter communicated to me by Dr J. Wilhelm I. Holst, Oslo.
3. Niels Stensen's genealogical table. See *Epistolae*, II, pp 898-906, and *Biography*, I, p 18.
4. *OTH*, I, p 394.

to his teachers.[5] A third person who influenced Niels's development was Simon Paulli (1603-1680), professor of anatomy 1639 to 1648, Royal Physician in the 1650's, and still renowned for his botany, the first *Flora Danica* from 1648. Stensen's regard for Simon Paulli was "as a respectful son", and he recalled having been brought up with Paulli's son, Jacob Henrik.

In 1654, during Stensen's school days, an epidemic broke out killing about 9,000 people, or one third of the city's population. This must have affected Niels deeply for, from his school alone, 246 pupils died.

1.2 At the University 1656-1659

In 1656, at age of eighteen, Niels matriculated at Copenhagen University under the latinized name of Nicolaus Stenonis, which was often shortened to "Steno".[6] As preceptor he had the *medicus primus*, Thomas Bartholin (1616-1680), who was famous for the detection of the lymphatic vessels in humans and for the *Anatomia reformata*,[7] or *Bartholinus's Anatomy*, revised from his father Caspar Bartholin's universally used textbook. After years of study in foreign countries, Thomas Bartholin was personally acquainted, and corresponded, with leading scientists all over Europe. At home, he and his family played a decisive role in matters relating to the university. By 1656, Thomas Bartholin was, however, no longer lecturing in anatomy, and the regular instruction fell to Christen Ostenfeld (1619-1671). Ostenfeld was a better jurist and administrator than a scientist, and he had little impact on the medical school. But in 1657, an abler man returned to

---

5. *OPH*, I: 5, p 77.
6. The French version of the name is *Nicolas Sténon*, the Italian version is *Niccolò Stenone*. In Denmark, the last name (which was not a family name, but means son of Steen) is spelled Stensen as often as Steensen. Since the former version has been used in most of the literature, and gives the most "correct" pronounciation for foreigners, Gustav Scherz chosed this spelling, mindful that the only Danish signature preserved is that of *Nicolaus Steensen* – apparently no contemporary source exists with the Danish 'Niels' as the first name. Let me add to the pragmatic view of Gustav Scherz, which I endorse, that uniform spelling facilitates both librarians' indexing and search on computers. As evident from several sources the shortened version *Steno* was used by others during his life-time and, as a matter of fact, in the parish register of Schwerin at his death: *Defuncti sunt ... D. Nicolaus "Steno" Episcopus Titiopolitanus Vicarius Apostolicus.*
7. *Anatomia, ex. Casp. Bartholini Institutionibus omniumque recentiorum et propriis observationibus tertium ad sanguinis circulationem reformata cum iconibus novis accuratissimis.* Leiden 1651, numerous Latin editions, four Dutch editions, and English edition 1668. Cf. Djørup, p 12.

Copenhagen after ten years of study abroad, Rasmus Bartholin (1625-1698), a younger brother of Thomas. Rasmus (or Erasmus) was a fine mathematician, trained as a physician in Padua, an excellent teacher, and a Cartesian scholar as well. Most of the basic training must have been in his hands. To judge by his student notes, Niels received quite a qualified instruction, including the study of recent and classical literature. This was facilitated by the inauguration of a reformed University Library in 1657, the old library dating back to 1482. Instruction at the medical school consisted of lectures, but *autopsia*, looking for oneself, had been encouraged by Ole Worm (1588-1654), the late professor and rector of Copenhagen University.[8] Dissections became part of the medical teaching from 1644 by the establishment of a *Domus anatomica*.[9]

Niels Stensen studied at Copenhagen University from 1656 to 1659, one of the most perilous and difficult periods in the history of the university, of Copenhagen and of Denmark generally. Following the Danish King Frederik III's declaration of war in 1657, the Swedish King, Carl X Gustav (1622-1660), invaded Denmark with an army through northern Germany. As Copenhagen, Denmark's capital, is located on the island of Zealand, it was well protected from hostile forces by a strong navy, but during the winter of 1658, the Great Belts were frozen over, thus enabling Carl Gustav to bring his force almost straight to the capital. The Danish king had to ask for peace. By the treaty of Roskilde, Sweden gained the Danish provinces east of Øresund, which were among the richest in the kingdom. But apparently this was not enough. Next year Carl Gustav waged war again, and besieged the capital, intending to take what remained of the country. But this time, Copenhagen was better prepared, and during the night of 11 February, 1659, the defenders repelled the main attack. A Dutch auxiliary navy brought relief, but the siege was not lifted on land until 1660.

The citizens played an important role in the defence of the capital. The stepfather of Niels was head of the Købmagergade Company, and Niels's name is listed on the roll of a student company for September, 1658. Niels certainly worked on the ramparts, but no evidence indicates that he was involved in direct action.[10]

Teaching at the university came to a near halt during the siege. There is, however, a record of Stensen's continued diligence in his studies: during four months in 1659, he filled 92 folio pages with closely writ-

---

8. Schepelern, *Museum Wormianum*, pp 156-57 and 377, see also p 16 (*Chaos*, N59).
9. Th. Bartholin, *Cista medica*, pp 185 ff.
10. Møller-Christensen, 1973.

ten notes on observations and small experiments, reflections, and extensive excerpts from the literature. These may have been intended as a source material to be carried along during planned studies abroad. The student notes are preserved in the Biblioteca Nazionale Centrale of Florence, Italy, where they were found in 1946 by the Stensen-scholar, the late Father Gustav Scherz. Recently, Danish and English translations by H.D. Schepelern, D.Phil., have provided scholars with a rare glimpse of what occupied the twenty-one-year-old medical student. The editions are entitled the *Chaos*-manuscript according to the inscription on page one, "In nomine Jesu, CHAOS" (Fig. 1). Often it is possible to determine where in the manuscript Stensen is quoting a teacher, resuming a general discussion or adding reflections of his own. Only the latter one third of the manuscript is presently edited.

Stensen was evidently a member of a small study group. Ole Borch is mentioned frequently; a professional soldier by the name of Hofman appears several times, and, now and again, the presence of a senior seems obvious. It might have been Rasmus Bartholin, but no firm indication is given.

Stensen described chemical experiments, many of them related to metals used in the workshop at home. He even mentioned the harmful effects of working with quicksilver: "it is often harmful to gilders, as their limbs become paralyzed and powerless, their nerves are weakened, indeed often when they put their hand to their mouth, they drop onto their side with cramp", *Chaos*, N 15. He reflected on a typically pastoral event like the production of heat in hay when stored wet. This was of practical concern in a city where cattle was kept inside the city wall.[11] On a different topic, Stensen marvelled at the multitude of forms of snow crystals in the winter and, when drawing some of them, mentioned the parallelepiped,[12] the geometrical figure later to be used as his model for the structure of compound muscles. He also mentioned that instruments of various kinds were used: balances, thermometers, and the newly developed microscope, and he outlined constructions for special equipment.

Several physiological experiments are mentioned. For one such experiment, Stensen suggested the use of an air-filled bladder to investigate respiration. Other experiments deal with the circulation of blood. It is particularly interesting that Stensen understood Harvey's theory

---

11. Descartes in several works discussed the heating of wet hay and other thermogenic reactions.
12. *Chaos*, N 18. Erasmus Bartholin in 1661 published a short treatise on snow crystals. Cf. Garboe, 1954.

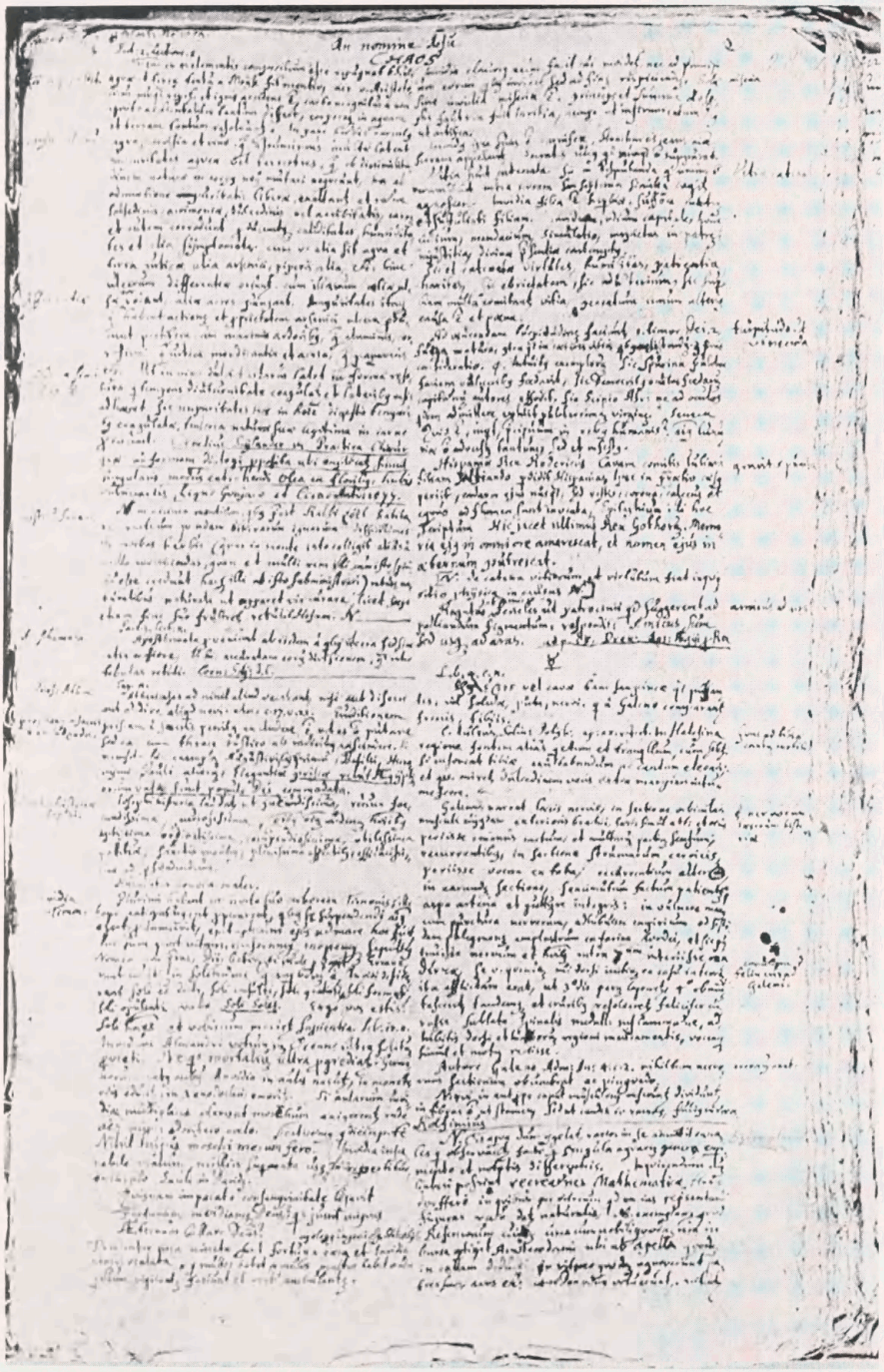


Fig. 1. The *CHAOS-manuscript*, Niels Stensen's notebook as a medical student in Copenhagen 1659. Biblioteca Nazionale Centrale, Florence: *Galilei 291;* Posteriori di Galileo, Tomo 32.

of the circulation, at that time still disputed,[13] well enough to describe a sort of liver-pancreas perfusion experiment. He also outlined the construction of an artificial heart:

> Could the movement of the heart be imitated if one took a little bladder which by means of some membranes and adhesives was shaped into two ventricles, to which arteries or nerves were joined, and an instrument was made for it which, as the balance in clocks does, continually at definite intervals squeezed the bladder together and thus pressed the blood that has been poured into it out into the arteries? (*Chaos*, N 160).

In another place Stensen reported that "against the swelling in scurvy, Monrad commended lemon juice, which was to be kept in the mouth."[14] He mentioned that one could extract a remedy against scurvy from the Danish Cochlear plant. "In medical practice," he reflected, "one must strive assiduously for the patient to maintain a steadfast hope, and medicines must not always be given in the same form, for variety pleases the patient greatly, and he must not take a medicine believing that it will not benefit him more than what was given him before." *Chaos*, N 206.

In an excerpt of Samuel Sorbière's 1654 work Stensen noted reservations about the practice of medicine:[15]

> Thus in medicine we learn nothing beyond uttering some words whose meaning taken separately is sometimes not unreasonable, but when seen in context have no useful sense ... When I see this, I begin to fear that someone might define medicine as: (1) The art, with furrowed brow, of uttering inanities to the patient and of using uncertain medicaments in order to ease slightly the worries of the mind and so that restoration of good health may occur calmly, while nature does its part of the work, or death can be awaited when fate takes its course. (2) A source of holding forth nonsense and peddling yard-long words which have a sound of something great, though they have no clear meaning; arbitrariness in prescribing quite uncertain medicaments as if they were effective. Audacity to boast of the happy results of one's own arbitrariness and to reject criticism of the bad ones, along with the knack of directing criticism at other authors.

In 1667, after having studied at centres of learning in three foreign countries, Stensen did not change his opinion of the practice of medicine, as the following remark in the introduction of *Elements of Myology* indicates:

---

13. Gotfredsen, 1957, pp 27 ff.
14. *Chaos*, N 154. Johan Monrad (1638-1709), later a councillor to the state, may have been a fellow student.
15. *Chaos*, N 221 and 222. The excerpt from Sebastian Aletophilus (thought to be a pseudonym of Samuel Sorbiére 1615-1670) is dated, Paris 1654, in the *Chaos-manuscript*.

> Nevertheless, we drag the wretched sufferer among thousand tortures, we even drive him to a thirsty death through a thousand torments. Our greatest misfortune is that often when we believe to be helpful, then indeed we are most harmful.[16]

Only three years later, the Grand Duke of Tuscany, Ferdinand II, to whom these words were dedicated, fell ill and died of dropsy and apoplexy. He suffered to the end just as much from the treatment of his doctors who, not content with bleeding him, placed a cauterizing iron on his head and forced *polvere capitale* up his nose; they also applied to his forehead four live pigeons whose stomachs had been ripped open.[17] At that time, however, Stensen was away from Florence in the Netherlands. Understandably, Stensen never became an active member of the medical profession, and when in 1671 he gave some dietary recommendations to Marcello Malpighi in a letter, *E* 65, the advice was accompanied by the following remark: "I do not dare to speak as a physician, since I have no such practice."

In the *Chaos*-manuscript, there are excerpts from no less than seventy-five authors.[18] Among these are works by Galileo Galilei, *Siderius Nuncius*; Francis Bacon, *De dignitate et augmentis scientiarum*; and René Descartes, *Discours de la méthode; Meditationes de prima philosophia*. Other writings by Stensen's compatriots, Tycho Brahe and by Petrus Severinus, *Idea medicinæ philosophicæ*, and several of Stensen's contemporaries indicate schooling in philosophy and science. However, further study will require a transscript and translation, a task currently under way by August Ziggelaar. Several of Stensen's own notes[19] and one of the manuscript's largest excerpts relate to motion, empty space, and the atomic theory of Epicurus as revived by Pierre Gassendi in *Animadversiones*. Gassendi was one of the most important opponents of Descartes. The young student also mentioned criticism of Descartes:

> There are some people in Belgium who, after a careful examination of the philosophy of Descartes, noted that there are certain things there which are not to be approved. Also there is someone who has written against him geometrically (*Chaos*, N 234).

Throughout his work, Stensen avoided arguing from occasional analogies to explain causal relations. Analogies used by Stensen serve as characterizations to the benefit of understanding, rather than as proof.[20] He explained why, and ended up touching on the problem of induction:

---

16. *Steno on Muscles* p 87. References to *OPH* 22 are to this edition.
17. Cf. Hibbert, 1980, p 293.
18. *Chaos*, pp 109-124. See also Snorrason, 1968.
19. *Chaos*, N223, 224, and 225.
20. Cf. Kardel, "*A specimen of observations*", 1986, p 112, note 35.

> It is a remarkable error of those who in the natural sciences wish to describe phenomena by means of comparisons, like Peiresc, who in his biography will have it that every light is a thin little flame which burns as long as it holds together, just as steam is rarefied water which appears as liquid when collected; if these things were correct, the result would be that just as steam does not disappear at the moment the water from which it comes is removed, so the light should not disappear either, when the sun or the candle from which it comes is gone, which is not true, because steam does not instantly disappear from the room as light does, etc. In the same way it has been said that the fetus is fixed by the umbilical cord in the womb just as plants are by their root in the soil ... In the sciences these comparisons do more harm than good, as the likeness which is used is better known, so that the mind thinks that the same thing which is seen here can be applied to another phenomenon (*Chaos* N 90).

The *Chaos*-manuscript does not disclose information on the writer's family life or the war. Only occasionally are observations included on the environment, e.g. a peculiar light, a halo around the sun, observed one day when coming from church. Another cold day he remarked "we did gymnastics against the cold" *Chaos*, N 11.

On Friday, 18 March, 1659, there is one short, all too human, remark: "Nothing done today." Several notes, but few quotations, have a religious or moral character:

> The Lord's name be blessed for ever and ever! Always and everywhere one ought to seek occasion to observe and imitate that which conduces to make life pious, seemly, and prudent, for the present or the future. If God some time makes me the father of a family, then with my whole house I shall praise God on feast-days, on the eve of them, with prayer and hymn-singing and find my joy in that (*Chaos*, N 67).

Assiduity, piety, attentiveness to own observation, and critical reflection seems to run like a thread through the student's notes, as they did later in his research:

> One sins against the majesty of God by being unwilling to look into nature's own works and contenting oneself with reading the works of others; in this way by being unwilling to look for oneself one forms and creates for oneself various fanciful notions and does not only miss the enjoyment of looking into God's wonders, but also wastes the time which should be spent on necessities and to the benefit of one's neighbour, asserting many things which are unworthy of God. Such are these scholastics, such are most philosophers, and those who devote their whole lives to the study of logic. Time is not to be spent on explaining and defending these opinions, indeed scarcely on examining them, and one must not boldly and impetuously assign anything to art on the basis of observing a single thing. From now on I shall spend my time, not on meditations, but solely in investigation, experience, and the recording of natural objects and the reports of the ancients on the observation of such things, as well as in testing out these reports, if that be possible (*Chaos*, N 59).

Perhaps, in these words lie a key to the understanding of Stensen's general method of science, namely his demarcation criterion. They may also explain why Stensen did not refer more often to the works of others: he found it a waste of time to examine and discuss specula-

tive works. Writers on Stensen from the time of Portal and Gosch, have tended to attribute the small number of references to ignorance, a point of view articulated even today. This position must be rejected on the evidence of the *CHAOS*-manuscript. Also the correspondence reveal remarks on books which Stensen borrowed, thus from the noted librarian, Antonio Magliabechi.[21]

Two more things are implicit in the student notes: first, the high quality of teaching received in school and at university, both in literature and in the natural sciences, in spite of devastating epidemics and war; second, the access to well-furnished libraries and information on how to use them.[22]

Another facet of Stensen's personality is revealed in two poems from the student-years.[23] The first poem is an epigramme printed at a funeral in 1657, thus being the earliest of Stensen's writings preserved. The first line reads like an apt description of the author and his stoical position: *Vita suis contenta bonis est optima vita*, or "A life, content with one's good things is the best life". The second poem, an elegy for the wedding of his fellow-student, Jacob Henrik Paulli in 1661, plays on a metaphor with two meanings: *Omnis amor jugum est*, that is "All love is a yoke" – a tool of daily life one can lift with or be stemmed down by, *conjugium* being the Latin word for marriage.

Before the end of 1659, Stensen was allowed to leave Copenhagen, which was still encircled on land by the enemy. He must have travelled by ship to the old Hanseatic and university city of Rostock, because later he counted among his teachers, professor Johan Bachmeister the Younger (1624-1689) of that city.[24] From Rostock, Stensen went to Amsterdam, a bustling centre for shipping and commerce, then five times larger than Copenhagen.

---

21. *E* 27a, 27b=58, 59, 60, 76, 84a, 101, 112a=103, 154a, 193a.
It is evident from these letters that Stensen regarded Magliabechi as a good and reliable friend. Nordström, however, in 1962, has revealed the correspondence between the latter and Jacob Gronovius in 1674–77 characterized by mistrust and aversion against Stensen and contempt of Stensen's theological works from 1675–77. Other targets for Magliabechi's scorn were Stensen's friends Francesco Redi and Vincenzo Viviani and the Grand Duke, Cosimo III.
22. Snorrason, 1968.
23. Scherz, *Nicolaus Steno and his Indice*, pp 290-91, Kardel 1988, and Olden-Jørgensen, *Niels Steensens digte*, 1992. It is notesworthy that Jacob Henrik Paulli did not include Niels Stensen in his booklet with epigrammes on old academic friends, the *Epigramatum promiscuorum libellus*, Strasbourg 1664.
24. Møller-Christensen, 1973, p 182.

1.3 In Holland 1660-1663

Like so many students of that time, Stensen embarked on a grand educational tour.[25] The Netherlands, Northern Germany, and Basel were visited most frequently by Danes. For students on the road for five to ten years, study at universities in Italy and France was usual.

Niels Stensen's writings convey the clear impression that he was on a low budget tour, sometimes lacking the means for obtaining sufficient study material.[26] In March 1660, he arrived at Amsterdam, where he received tuition and lodging from the City Physician, later Professor, Gerard Blaes (Blasius) (1626-1682), who had studied at Copenhagen and was a friend of Thomas Bartholin.

After attending Blaes's lectures for a couple of weeks, on 7 April, 1660, Stensen asked permission to undertake a dissection on his own. In a letter to Thomas Bartholin a year later, Stensen recalled what happened:[27]

> After I had been given leave by Blaes to dissect on my own in the museum, I bought a sheep's head in order to examine the brain. I happened to decide to investigate first the course of the veins and arteries at the mouth by introducing a probe in the vessels. I suddenly discovered that the point of the probe was moving freely in a spacious cavity and struck with ringing sound against the teeth. Surprised at this, I called my host to hear his opinion. Blaes first said that it was due to force, then that it was one of nature's frequent freaks, and finally he looked up Wharton's book [*Adenographia*, 1656], but found no explanation there.

Some days later, Stensen repeated the investigation in a dog. He now felt certain that the duct was an excretory duct leading saliva from the parotid gland to the oral cavity. The parotid gland was a well known

---

25. In his *On Medical travel*, p 58, Thomas Bartholin made the following recommendations for his nephew, Holger Jacobæus, and son, Caspar Bartholin Jr.:

> To speak more clearly and without enigma, the principles of the art are taught both at home in our native land and in the neighbouring Low Countries; medical training and anatomical dissection flourish in Paris and Padua, and botany is exalted at Montpellier and in Montauban; Germany teaches pharmacy and chemistry, experiments are made in London, Florence etc. Paris and Italy stand forth in dexterity of the surgical art. The Parisians and Romans search the oracles of Hippocrates, the Paduans follow in the footsteps of Galen, and those of Montpellier boast themselves as the heirs of Arab doctrine carried to them by the disciples of Avicenna and Averroes who flourished for many centuries in the Academy of Cordoba through the diligence of the Moors. The Germans, followers of all sects, even join the medicine of Paracelsus to the rest in a friendly union. However, the British, fortunate in the fruitfulness of talented men and the essential supply of subsidies, exert themselves strenuously in new things wholly founded on experiments.

> Ancient trends in local medical traditions seem to flourish: similar patterns are revealed in today's medical practice by Payer, 1988.

26. *E* 1, 5 and 7.
27. *E* 1. Translation quoted from Moe, 1986, p 53.

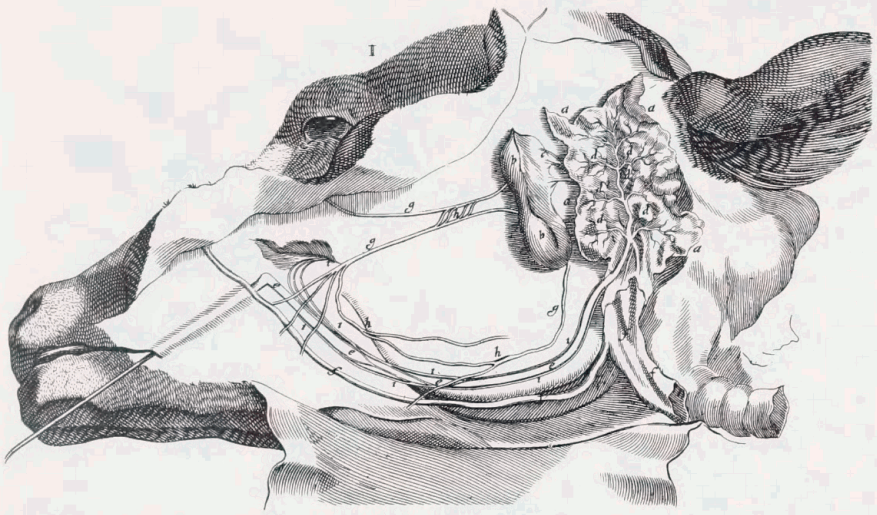


Fig. 2. A probe inserted into the secretory duct of the parotid gland of a calf. *De glandulis oris*. Leiden 1661.

structure, but looking like a sponge its function was thought to be like a sponge intended to absorb surplus materials, and also to carry nerve juice back to the veins, warm up the outer and inner ear, and fill up the hollow around it.[28] Once again Stensen showed the finding to Blaes, but then they did not talk any more about it. On 8 July, Stensen defended a thesis on quite another issue, nineteen short paragraphs *On hot springs*.[29] Soon after he left Amsterdam to register at the famous university at Leiden on 27 July, 1660.

Stensen showed the parotid excretory duct to the professors Jan van Horne (1621-1670) and Frans dele Boë Sylvius (1614-1672), who recognized it as an original observation. Van Horne performed a demonstration in the anatomical theatre, naming the vessel *ductus Stenonianus* (Fig. 2). A presentation was also made in the presence of the visiting professor from Copenhagen, Ole Borch. At the same time, Blaes demonstrated the duct to his students in Amsterdam as his own

28. Moe, 1986, pp 53-55. Wharton, 1656, p 127. Descartes described the origin of saliva as follows, "In addition, some particles of blood proceed to the spleen, and others to the gall bladder. And – from the spleen and the gall as well as from the arteries directly – some particles reenter the stomach and the bowels where they act like aqua fortis to help the digestion of food. And because these are brought here from the heart quasi-instantaneously, they are invariably very hot, which enables these vapors to rise easily through the gullet toward the mouth, there to compose the saliva". *Treatise of Man*, ed. T.S. Hall, p 16.
29. Scherz, 1960 and *GP*, pp 50-69.

discovery, and published it in his *Medicina generalis* in 1661. A priority dispute ensued between the young graduate student from Denmark and the established professor, a fairly uneven matching. Disputes on priority were, however, quite common at that time. Some ten years earlier Thomas Bartholin was involved in a fierce dispute with Olaf Rudbeck, a young student of Uppsala, Sweden, over the discovery of the lymphatic vessels.[30]

The dispute between Stensen and Blaes was not only one of honour, but also, for the young student, a question of honesty.[31] Several Dutch writers attacked Stensen and supported Blaes. Stensen responded fiercely: "[Blaes] ascribes to the gland a function that is so unimportant that if I were not certain that I had shown him the duct, I might allege that he had never seen it."[32] Thomas Bartholin gave his word of consolation and tried to remain neutral between pupil and friend:[33] "Your situation makes me feel pain while such important adversaries surround you. But it may be beneficial to eminent talents with honest rivalry" (*E* 14). Stensen, as he explained to Thomas Bartholin, had indeed been struck by *invidia*, envy.[34] The resulting two polemic publications[35] against the assaults from Deusing and Hoboken are usually regarded with forbearance due to the author's youth, but most often they are simply overlooked. By doing this, however, one overlooks the author exposing his method when comparing scientific theories. Detailed arguments are matched, sometimes printed in double columns for comparison, a technique later to be applied on theological controverses.[36] Stensen's wrestling with contemporary biologists may well be compared with Galileo's in cosmology. Stensen: "The *Prologue of the Apologia* [*OPH* 13] published a year ago has clearly exposed in what consists its difference from this duct described by Blaes which is not to be found by any other than the author, except perhaps in the inhabi-

---

30. Lindskog, 1989-90.
31. Stensen in the letters *E* 1, 3, 5, 7, 9 and 10 told Thomas Bartholin of the dispute with Blaes.
32. Moe, 1986, p 61.
33. *E* 2, 4, 6 and 14.
34. Also Tycho Brahe, Denmark's first renown scientist, wrote in his *Elegy to Denmark* that he was struck by envy.
35. *OPH* 9 and 13. English translation by Paul Maquet to be published.
36. *OTH*, I, p 470-74. See also Scherz in *OTH*, I, p 377:

    Als Grundlage für einen *Vergleich zwichen dem Katholizismus und den andern Kirchen* stelle Stensen folgende Punkte auf: 1. Christi wahre Kirche hätte einmal im Katholizismus existiert. 2. Die Vorväter der reformierten Genossenschaften hätten, als Heiden, die Lehrer vom Katholizismus empfangen. 3. Sie hätten dem Papst den Treueid geschworen. 4. Nur göttlische Autorität könne sie davon entbinden. 5. Alle diejenigen, die vor Luther fromm im Katholizismus starben, seien in der Hoffnung auf das ewige Leben gestorben.

tants of the moon or those crawling in the spaces between the worlds of *Epicurus* [i.e. empty space]".[37] The argument over the priority for detecting the excretory duct of the parotid gland only ceased when Stensen became famous for so many other discoveries.[38]

The incident spurred Stensen on to make further investigations of glands in the mouth, nose, and behind the eyelid – he wrote explicitly that he had drawn benefit from the envy! The lateral nasal gland ("Steno's gland") was described in sheep and dog. It is, as he mentioned, not found in man.[39] Another first description is the ductus naso-palatini, *OPH* I,15:185. Inspired by Sylvius, Stensen distinguished glands with an excretory duct from those without, the lymph glands, and he discovered the excretory canaliculi leading tears from the lacrimal glands. These glands, called *glandulae innominatae* by Wharton,[40] had been known since Galen, but they were considered far too small to be the source of the tears, which were thought to come from the brain.

It is obvious that Stensen drew benefit from a close acquaintance with Thomas Bartholin's works on the lymphatic vessels from 1652-54. In the *Responsio ad vindicias hepatis redividi*, *OPH* 4, Stensen was defending more the position of Thomas Bartholin than presenting observations of his own: that chylus does not flow from the intestines to the liver, but flows towards the receptaculum and the thoracic duct, and from there to the heart. Accordingly Thomas Bartholin had "dethroned" the liver from its former supreme position in the hierarchy of organs in the teaching of Galen. But without further evidence Bartholin replaced the liver with the heart as the seat of blood formation.

---

37. *OPH* I: 15, p 183, 1664.
38. *E* 11. The dispute was mentioned probably for the last time in the review of *De musculis* by the *Journal des sçavans* on 23 March 1665, p 160; pagination refers to the 1679 Amsterdam edition:

    > Tout ce qu'on dit contre Monsieur Stenon, est qu'il a dérobé des uns & des autres toutes les nouveautez dont il se pretend l'inventeur: car dés l'année 1663, il parut à Utrecht un livre, sous le titre de *Novus ductus Salivalis Blasianus, in lucem pertractus à Nicolao Hoboken*, dans lequel on l'accuse d'estre plagiare, & d'avoir appris de Blasius le nouveau conduit Salivaire, de l'invention duquel il le fait Auteur. Mais Monsieur Stenon répondit aussi-tost à ce Livre, par un Prodromus [*OPH* 13], où il montre que Blasius est un ignorant dans la Medicine, & incapable d'y faire aucune nouvelle découverte. Et il fait voir que le conduit Salivaire que cét Auteur pretend avoir découvert, est toute autre chose que celuy qu'il décrit.

    In the 1696 edition of Vesling's *Syntagma anatomicum*, (dedicated to Blaes!), there is a large excerpt of Stensen's treatise on the salivary glands and also a reprint of Stensen's illustration of the excretory duct of the parotid gland quoting rightly the source. Only in a foot-note it is mentioned that the duct was called *novus ductus salivalis Blasianus* by Professor Hoboken of Steinfurt [pp 465-70].
39. *OPH*, I: 6, p 95. Cf. Moe & Bojsen-Møller, 1971.
40. Wharton, 1656, pp 182-174 (sic!).

Ironically, Stensen was then to "dethrone" the heart as well, thereby challenging a main point of his teacher[41].

Stensen's research on glands was published at Leiden.[42] As elucidated by Portal,[43] by Julius Petersen,[44] by Ulrike Heida,[45] and by Harald Moe,[46] they brought new esteem to glands by raising them from their traditional lowermost rank in the hierachy of organs, and thereby established the study of glands as a science. How well Stensen's small treatises from 1661 and 1662 were received is evident by the fact that Thomas Bartholin presented one of them to the Danish King, Frederik III.[47] On 2 January, 1662, in a letter to Thomas Bartholin, Ole Borch wrote of Niels Stensen: "In truth he is a genius, worthy of growing into his country's hope."[48] In the Netherlands, Reinier De Graaf referred in 1664 to his "most honest friend's" discoveries.[49] In Germany, Heinrich Meibom in 1666 referred to the vessels of the eye-lid: "Stensen gave us far more detailed information on these vessel ... which no-one ignores any longer".[50] In Italy, in a letter to Marcello Malpighi dated 15 February 1663, Giovanni Alfonso Borelli[51] noted that the parotid duct, detected by Stensen, was demonstrated by Lorenzo Bellini for the Grand Duke of Tuscany and a group of English scientists, who declared that they had never before seen such a structure. In November, 1664, Malpighi, in a letter to Borelli, praised Stensen's detection of the glands of the palate.[52] Also Simon Paulli praised in 1674 the pupil "to whom I pass on the torch of life" for his achievements in glandular research.[53]

My comment on Stensen's research in glands is that from the beginning he applied a technique of continual matchings between obser-

---

41. Stensen's adversaries evidently in vain tried to make bad blood between Bartholin and Stensen as they tried to do between Stensen and his professors van Horne and Sylvius.
42. *OPH*, works no. 2, 4, 5 and 6.
43. Portal, III, pp 163-72.
44. Jul. Petersen, 1898, pp 74-112.
45. Heida, 1986, pp 25-35.
46. Moe, 1986.
47. *E* 6.
48. *Dignum sane ingenium est, quod in spem patriæ adolescat.* Cf. Christiansen and Moe in the introduction to *Chaos*.
49. *amico meo integerrimo.* See also De Graaf, *Opera Omnia*, 1677, p 508:
    Ad distinctionem Ductum salivalium superiorum.. Quorum inventionem debemus Nicolao Stenoni Dano, qui eos Anno 1661 in libello suo publici juris fecit.
50. Cf. Jørgensen, 1884, p 96.
51. Adelman, 1975, letter 72.
52. *In palatinis glanduli à laudato Stenone observatis*, Malpighi, *Epistolæ Anatomicæ*, 1687, p 19.
53. Andersen, *Simon Paulli, Beretning over en kongelig ridehest*, pp 66-67.

vations and the descriptions in the literature which had formed his anticipation or mental model.

After completing the works on glands, Stensen for a time was inclined to give up the study of anatomy in favour of geometry, but considerations on his future career made it necessary for him to return to the "bloody task" with the scalpel in place of the compasses.[54] On 26 August, 1662, Stensen mentioned in a letter to Thomas Bartholin[55] two additional reasons for his return to anatomy: new observations concerning the contraction of the heart, and the posthumous first publication at Leiden in 1662 of Descartes's *Treatise of Man*, to become published in the original French in 1664 (The treatise had been completed probably in 1633 but suppressed by its author during his lifetime). Stensen remarked that this work contained "figures which are not inelegant and which certainly comes from an ingenious brain; but I truly doubt whether a brain like that described is ever to be detected."[56] Thus, he embarked on studies of the heart, muscles and the brain, probably with the aim of studying the interaction of the soul in locomotion. Like previous studies on glands and subsequent studies on geology and fossils, one particular observation or statement in the literature triggered his scientific activity by arousing disagreement.

1.4 Studies of Heart and Muscle

In 1662, Stensen studied how the heart of a young raven continued to contract after the animal was opened. When, after two hours, the heart slowed down, an observer of the dissection, Dr Willem Piso (1611-1678) of Amsterdam, mentioned that earlier he had seen dogs in which the region of the heart closest to the vena cava had been the last part to die.[57] Stensen verified this sequence in the bird, and later confirmed the observation with additional studies in rabbits. In a letter made public by Thomas Bartholin,[58] Stensen delineated what is today called the sino-atrial and atrio-ventricular dissociation.

In a subsequent letter, dated 30 April, 1663,[59] Stensen described the

---

54. *E* 9.
55. *OPH*, I: 9, p 115 and 120.
56. Already on 21 May, 1662 (*E* 7), Stensen in a letter commented on Descartes's erroneous account on the source of tears.
57. Thomas Bartholin, in his response (*E* 10) referred to an earlier, similar observation by Johannes de Wale (1604-49), professor of medicine at Leiden, probably the *Epistolæ duæ de motu chyli et sanguinis*, 1641.
58. *E* 9=*OPH* 9.
59. *OPH* 14=*E* 13.

course of the muscle fibres forming *spiral* loops around the ventricle of the heart. Later, in an examination of muscles in general, Stensen stated that nothing is found in the heart which is not found in a muscle, and nothing is missing in the heart that is found in a muscle. To reach this understanding Stensen had studied the structure of muscles in general. He described how his studies began in *De musculis*, 1664. More details are found in a letter 1678 to Gottfried Wilhelm Leibniz:

> I will tell you that when I lived in the country of freedom, in contact with very free-thinking people, and read all sorts of books, then I had great esteem for Descartes's philosophy and for all those people praised for their knowledge of Cartesian philosophy. When a Swedish friend of mine brought in the lungs of a cow, attached to the heart, in order to study the substance of the lungs, after finishing the examinations of the lungs we wished to boil the heart to see whether its substance was muscular; and the first fibers of the heart, which I touched after having peeled off its membrane, led to the apex and from there upwards again, an arrangement which contains a truth explaining the entire structure of the heart, about which until that moment I had heard no one tell, and which is directly contrary to what the greatest and most dangerous philosophers held as a demonstrative truth even to the extent that they held that those who did not accept their opinion on the heart did not understand anything in mechanics. One afternoon a short time later, I wished to draw a comparison between the structure of the heart and that of muscle, about which I held the system of Mr Descartes infallible. To that end, I took the leg of a rabbit, which I had dissected a short time earlier, and in which in the first muscle and by the first cut, I revealed the structure of the muscle, which up to that time had not been known to anyone, and which finding reversed the whole system of Mr Descartes (*E* 143).

Stensen then wrote that he expected soon to write more on the heart and muscles; his present letter was mainly intended to learn from Thomas Bartholin whether he had any similar experience which would then save him the cost and trouble of further examinations.

Bartholin answered on 4 August, 1663 (*E* 14). He discussed Stensen's description of the arrangement of fibres in the heart, but did not comment on the sketches of the structure of skeletal muscles. He praised Stensen for the assertion – contrary to his own position! – that the heart is only a muscle, which revived a concept of Hippocrates abandoned by Galen. About this Stensen later wrote: "I am not ignorant that Galen tells us in express words, that those who assert the heart to be a muscle, understand nothing."[60] In the letter to Thévenot following the *Elementorum*, Stensen added that most of the controversy between followers of Hippocrates and Galen on the structure of the

---

60. *De musculis*, Kardel, 1986, p 106. Galen described the heart as being a hard organ, which does not easily suffer from damage. Being composed of fleshy fibers it resembles muscles, but has not little distingushing it from them. Cf. Wiberg, 1910, p 30.

heart was due simply to the lack of a method to recognize the heart's structure. Bartholin's letter ended: "congratulations, my dear Stensen, on your zeal. Continue to gain a reputation from this and from similar sorts of writings, and be sure to have in me a friend."

The text and sketches of the structure of muscles in Stensen's letter from Leiden, published by Thomas Bartholin in 1667 as *Nova musculorum & cordis fabrica*,[61] contain the outline of the theory of muscle contraction elaborated in *De musculis*[62] in 1664, and completed in the *Elementorum myologiæ specimen*[63] in 1667.

Another source from the period in which Stensen began his research on the heart and muscles, is the travel itinerary of Ole Borch. From notes dated Leiden, 3 February and 3 May, 1663,[64] it appears that Borch observed muscle research: in the margin Borch drew a diagramme of a bipennate muscle similar to Stensen's.

From the very beginning of the sojourn in the Netherlands, Stensen showed great skill as a scientist. As at home, an active academic environment at Leiden was a contributing factor, with pioneering emphasis on "experience sought on purpose", e.g. the physiological experiment.[65] During those years, Leiden produced scientists like Jan Swammerdam (1637-1680) and Reinier de Graaf (1641-1673), who became Stensen's friends. Oddly enough, none of these three highly distinguished men of science were successful in obtaining an academic career. At Leiden, Stensen also became acquainted with the lens maker at nearby Rijnsburg, the philosopher Baruch Spinoza (1632-1677), to whom he later published a letter on religious and philosophical questions (see section 1.11).

1.5 Back in Copenhagen 1664

By March 1664, at the latest, Stensen was back in Copenhagen after the death of his stepfather, Johann Stichman, in November 1663. In June 1664, his mother also died. His sister Anne's husband, Jakob Kitzerow, now took over the goldsmith's business. Whether Stensen hoped to obtain a chair at the university is not certain. A position was at that time offered to Matthias Jakobsen, Jacobæus (1637-1688). In 1992 Olden-Jørgensen concluded from a re-evaluation of the sources

61. *Steno on Muscles*, pp 61 ff.
62. Kardel, 1986, "*A Specimen of Observations on Muscles*".
63. *Steno on Muscles*, pp 77 ff.
64. Borch, 1983, II, pp 272 and 297.
65. Lindeboom, 1975, p 290.

that Thomas Bartholin, the brother of Jakobsen's mother, is less to blame for this decision than the two professors, Erasmus Vinding and Peder Scavenius, the brothers-in-law of Jakobsen.

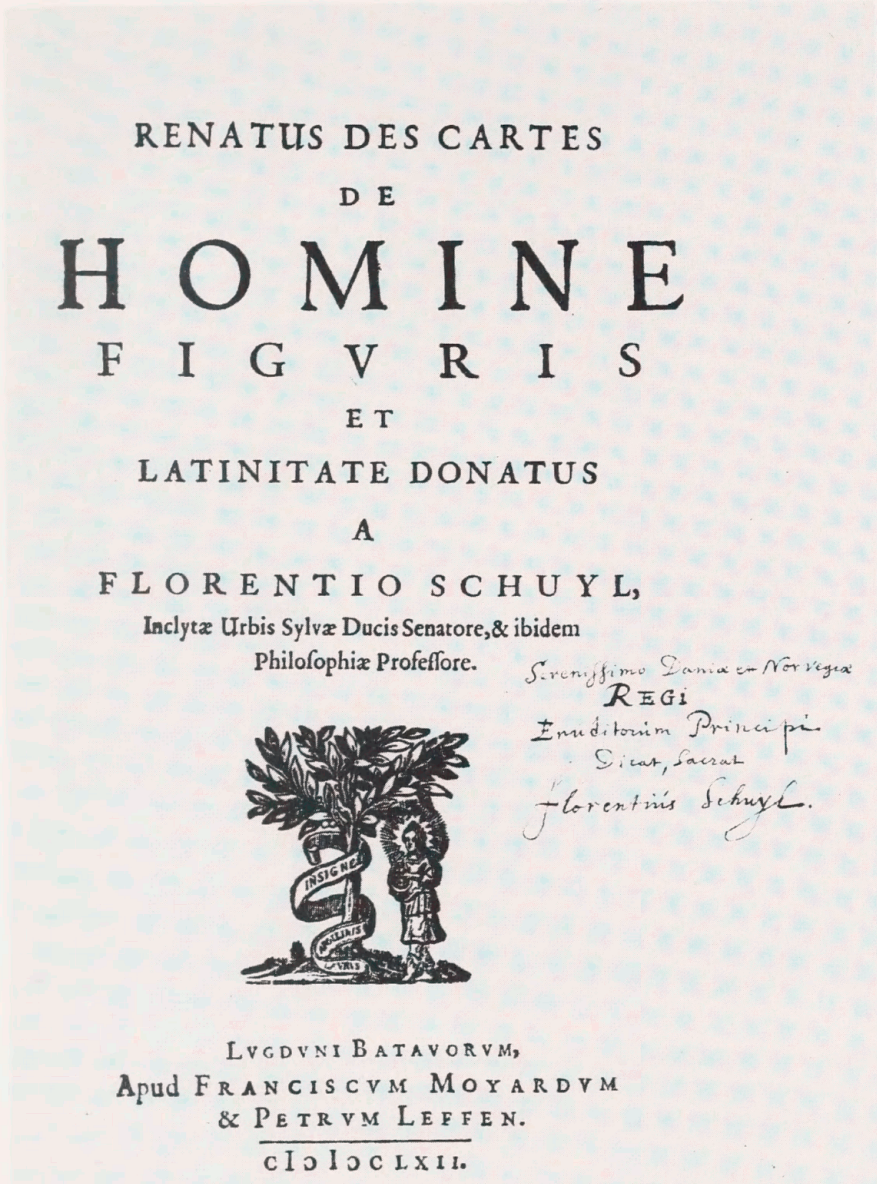
Most certainly, Stensen did receive the support of professor Thomas Bartholin to publish, in a quarto dedicated to King Frederik III, "a short summary of what I hitherto have come to see in anatomy". I consider this as a bold publication in which, based on own investigations, the author rejected basic axioms in scholalastic teaching on the heart, on muscular contraction, and on glands. Throughout it expressed overt disapproval with the most recent publication by René Descartes. The posthumous work of the latter had been presented with hand-written dedication by the editor Florentius Schuyl to the Sovereign of Denmark and Norway (Fig. 3). King Frederik took an interest in science, in particular in anatomy as evidenced by royal attendance at least twice at Thomas Bartholin's anatomical dissections and by the royal monogram ornamenting the binding of Wharton's *Adenographia*, London 1656, now in the Danish National Library of Science and Medicine in Copenhagen. However, as a sovereign, King Frederik had other duties and responsibilities than sorting out academic disputes. My supposition is that Stensen by challenging the dead master of philosophy in his book dedicated to the king had gone far. So far, in a way, that I find some reason in the decision by the king's university, not, for the moment, to promote Stensen, in the interest of avoiding conflicts for the institution and its great sponsor, but to let Stensen go to France and convince Paris first.

The illustrations on the splendid baroque title page of *De musculis & glandulis observationum specimen*[66] are like an index of the work: muscle structure, tongue, heart, lymphatics, yolk sac. The style of the letters and the exactness of the anatomical details reveal Stensen's personal role in its creation (Fig. 4).[67] Two scientific letters were appended, one describing the dissection of two rayfish, the other rediscovering how nutriment in the chicken is carried from the yolk sac into the intestines through the vitello-intestinal duct.[68]

In the main section of the work Stensen wrote "that there is in the heart no parenchyma different or distinct from its fibres," that the cone, or apex, must be drawn upwards in the systole, and that the

---

66. *OPH*, 15. A complete translation by Paul Maquet awaits publication.
67. Snorrason 1986, p 187.
68. *OPH*, 17. For an English translation, see Margaret T. May: "On the Passage of Yolk into the Intestines of the Chick". *J Hist Med All Sci* 1950; 5: 119-43. This duct had been known by Aristotle. Stensen responded to criticism for taking priority in his letter to Thévenot. Cf. Biography I, p 111.



RENATUS DES CARTES

DE

HOMINE

FIGVRIS

ET

LATINITATE DONATUS

A

FLORENTIO SCHUYL,

Inclytæ Urbis Sylvæ Ducis Senatore,& ibidem

Philosophiæ Professore.

Serenissimo Daniæ ac Norvegiæ

REGI

Eruditorum Principi

Dicat, Sacrat

Florentius Schuyl.

LVGDVNI BATAVORVM,

Apud FRANCISCVM MOYARDVM

& PETRVM LEFFEN.

cIↃIↃCLXII.

Fig. 3. The title page of the first edition of René Descartes, *De homine*, with the editor's dedication to King Frederik III. The Danish National Library of Science and Medicine.

Fig. 4. Title page of *De musculis & glandulis observationum specimen*, Copenhagen 1664. Note the unipennate structure of skeletal muscle, upper left, and the muscular structure of the heart in side-view and cross-section.

walls will become both shorter and thicker during shortening of the fibres because of their course.

The Harvey-Descartes controversy on the circulation of blood and motion of the heart, basic to Stensen' research, was recently reconstructed by Geoffrey Gorham as follows. In *De motu cordis*, William Harvey described in 1628 the circulation of the blood as a result of movements of the heart. Blood is driven through the pulmonary circulation and at the same time through the aorta and arteries to return to the heart in a continuous movement. Descartes was soon to accept

the circulation theory, differing however on the heart's role. For Harvey the systole coincided with the beat of the pulse, the result of contraction of circular fibres of the heart. A "pulsatile faculty" was responsible for contractile movement. Harvey referred to the blood as the author of pulsation and life. Such vitalistic principles were contrary to the mechanistic observance of Descartes, according to whom local motion of bodies is brought about only by contact with other moving bodies, unless caused by the will of a conscious soul. According to Descartes drops of nutrified blood are heated on contact with the extremely warm walls of the heart by a certain "fire without light" residing in the pores of the heart. The rarefaction of the blood causes the heart to expand. Thus for Descartes, the diastole is synchronous with the beat of the pulse. According to Gorham the mind-body dualism combined with opposition to a vitalistic principle such as an innate pulsatile faculty of the heart responsible for its movement, prevented Descartes from accepting Harvey's theory on the heart's role in the circulation.[69]

Priority for the description of the spiral-shaped arrangement, as opposed to Harvey's circular arrangement of the muscle fibres of the heart, is quite often assigned to Richard Lower (1631-1691). In his *Tractatus de corde*, published at London in 1669, Lower illustrated the spiral arrangement of the fibres, but Stensen's detailed description preceded that of Lower by five years, and was referred to by Swammerdam already in 1667. Much later, Borelli also claimed priority for this discovery:[70]

> I was the first to see this admirable structure at Pisa in the presence of the famous Malpighi in 1657. Afterwards, others made the same observation. Finally, the famous Lower and Lorenzo Bellini investigated the exact texture of the heart by undoing the binding of the fibres, as complex as a ball of wool.

Annoyance over having been forestalled in the description of the heart may have cooled Borelli's feelings toward Stensen even before they met; or cool feelings may have blinded Borelli when later he reflected on what had passed.

---

69. A parallel to the Descartes-Harvey controversy on contraction of the heart is the later, almost endless, controversy concerning the contraction of skeletal muscles, Stensen versus Mayow, Borelli, Croone, Bernoulli, Boerhaave, and Haller (*Steno on muscles*, chapter 5). Inspired by Gorham, I suggest likewise that Stensen's deviation, flatly ridiculed by Bernoulli 1694, from the Aristotelean principle of movement, *Omne quod movetur, movetur ab alio*, combined with the mind-body dualism may have lead investigators, without understanding, to reject Stensen's geometrical theory of muscular contraction.
70. *De motu animalium*, 1680. Translation by P. Maquet in Borelli, 1989.

In 1664, Stensen concluded on the heart:[71]

> If therefore it is certain, as it is so beyond all Dispute, that we are convinced both by our Senses and Reason itself that there is nothing wanting in the Heart that is to be met with in a Muscle; and further, that nothing is found in the Heart but what is found in a Muscle, how then can the Heart be any longer a Substance of its own Kind, and consequently a certain determinate Substance, as the Fire, the seat of innate Heat, and the Soul; or the Procreator of some certain Humour, as of the Blood, any more than the Produce of certain Spirits called vital?

Simple statements today perhaps, but still basic to the understanding of the heart as a pump and of the theory of the circulation. "This work will turn upside down what is basic in medicine" was the comment from the *Journal des sçavans* of Paris in 1665, p 139. Stensen's description of the structure of the heart was thoroughly excerpted and reviewed in the *Philosophical Transactions of the Royal Society*:

> In the *Specimen* it self, the Author, having described in *general*, both the *Structure* and the *Function* of the *Muscles*, applies that description to the *Heart*, to demonstrate that *that* is also a *true Muscle*: Observing *first*, that in the substance of the *Heart* there appears nothing but *Arteries, Veins, Nerves, Fibres, Membrans*; and that that, and nothing else is found in a *Muscle*; affirming withall, that which is commonly taught of the *Muscles*, and particularly of the *Heart's Parenchyma*, as distinct from *Fibres*, is due, not to the *Senses*, but the *Wit* of *Anatomists*: so that he will not have the *Heart* made up of a substance peculiar to it self, not considered as the principle of *Innate heat*, or of *Sanguification*, or of *vital spirits*. He observes *next*, that the *Heart* performs the like *operation* with the *Muscles*, to wit, to contract the Flesh; which action how it can have a different cause from that of the Contraction made in the *Muslces*, where there is so great a parity and agreement in the *Vessels*, he sees not. And as for the *Phænomena*, that occur, of the *Motion* of the Heart, he undertakes to explicate them all, from the *Ductus* or *Position* of the *Fibres*; but refers for the performance of this undertaking to another *Treatise*, he intends to publish (1665-66, I: 176).

Thus, as described for the Royal Society in its first volume of the *Transactions*, Stensen attacked the arbitrary elements taught on the heart by Galen and adapted by Descartes and Stensen's teachers, Sylvius and Bartholin.[72] As well he attacked the vitalistic principles basic to Harvey. In 1661, Marcello Malpighi (1628-1694) had described the lung capillaries by microscopic examination in frogs,[73] which for the first time demonstrated how blood passes through the tissues. The works by Malpighi and Stensen extended the significance of Harvey's discovery of the circulation in 1628 into what is now often termed a

---

71. Kardel, 1986, p 115.
72. Jul. Petersen, 1898, pp 83-85.
73. Malpighi, *De pulmonibus. Observationes anatomicae.* Bologna, 1661. English translation in Fulton & Wilson, pp 68-71.

scientific paradigm. Today the *De musculis* is considered a classic work in cardiology.[74] It is equally basic on skeletal muscles:

> First, in all the Muscles there are to be observed Arteries, Veins, Nerves, Fibers, Membranes, and some add Lymphatic Vessels; Secondly, you shall never meet with any Muscle in which each single Fibre does not extend it self on both sides within the tendon. Thirdly, the fleshy part is not a *Parenchyma*, but the same Fibrils which, being closely conjoin'd within one another, do form the Tendon, being looser, constitute the fleshy Part. Fourthly, it is very hard to meet in any one muscle with a fibre which makes one straight line; but each of them is divided at least into three Lines, which comprehend two alternative angles. Neither are these Three Lines always straight.[75]

Next followed a description of the functional architecture of the skeletal muscles based on parallel fibres in ranks and orders. But, without illustrations, Stensen's first published attempt to describe geometrically the arrangement of skeletal muscle fibres is almost incomprehensible. Otherwise, *De musculis* is highly readable for all its details, but its wealth of loose endings overloads its structure. The great bibliographer of physiology, Albrecht von Haller (1708-1777), called it the golden booklet, *aureus libellus*.[76] In 1711 most of the section on heart and muscles was translated into English.[77]

My interpretation is that from the very beginning of dissections on his own at Amsterdam, Stensen researched the anatomical evidence for the animal spirit in locomotion. The fortuitous finding of the parotid duct and the dispute with Blaes's supporters held him up for a while in glandular research.

Commentators, from the first Danish biographer of Stensen, A. D. Jørgensen in 1884,[78] have lamented the decision not to offer Niels Stensen a position at Copenhagen University in 1664. From the standpoint of the university, they may be right, and their position finds support in the involvement in the decision of no less than the Rector of the university, professor Peder Scavenius. But, when comparing Stensen's *De musculis* with his *Elementorum myologiæ specimen* published three years later, I see little reason to lament the outcome.[79] In the right academic surroundings, an ingenious talent developed into the mature genius of a master; regrettably, however, no one for centur-

---

74. Willius & Keys, 1941.
75. Kardel 1986, p 109.
76. Haller, 1774, I, p 492.
77. Kardel, 1986, pp 105-15.
78. Jørgensen, 1884, p 69.
79. I share this position with Julius Petersen who in 1898 asserted that he could not imagine Stensen chairing the scholastic disputations and small-minded quarrels which formed the greater part of academic life at an orthodox university. *Bartholinerne*, p 90.

ies to come would understand fully the value of his masterpiece, the first description of the functional architecture of skeletal muscles.

After having received some inheritance, money owed to his stepfather by the king, Stensen left Copenhagen in the fall of 1664 for further studies abroad. His publications had given him a reputation that opened the doors to the world. Furthermore in December 1664 Stensen received *in absentia* the degree of Doctor of Medical Science by the Senate of the University of Leiden.[80]

1.6 In France 1664-1666

Stensen was in Paris from November 1664 until September 1665. He received the patronage of Melchisédec Thévenot (1620-1694), later the King's chamberlain, a man of means and scientific interest, and considered the gray eminence behind the foundation of the Paris Academy of Sciences in 1666.[81] Thévenot's houses at Paris and Issy were open to visiting scientists, among whom were Stensen's friend from Leiden, Jan Swammerdam. Faller has characterized this period as probably among the most carefree periods of the two friends.[82] They were joined also by Ole Borch. Although he mentions Stensen rarely, Borch's travel diary is a source of information concerning the scientific circles in which Stensen moved in Paris. Other contemporary sources are four letters to Stensen from another founding member of the Paris Academy, Jean Chapelain,[83] and letters by the physician, André Graindorge, who witnessed dissections by Stensen and reported on them to the later bishop of Caën, Pierre-Daniel Huët, a devoted anti-Cartesian writer.[84]

Scientific issues were discussed at weekly meetings, and it may have been at such a meeting during the winter of 1665 that Stensen delivered, in French, a lecture on the anatomy of the brain, which was published four years later, *OPH* 18. The *Discours sur l'anatomie du cerveau* is probably the best known of Stensen's works in biology and still considered readable by neuroscientists who can learn from its rigorous scientific thinking and advice on questions of methodology, e.g.: "Without opening the cranium, attempts could be made to apply dif-

---

80. *E* 17.
81. Schiller & Théodoridès, 1968.
82. Faller, 1986, p 241.
83. *E* 18, 20, 23, and 24.
84. Eighteen letters in the Royal Library, Copenhagen (Kgl. Bibl. Ny kgl. Samling 4660, 4°). Transcripts in: L. Tolmer, *Une page d'histoires des sciences 1661-1669. Vingt-deux lettres inédites d'André de Graindorge à P. D. Huët, Mémoires de l'Academie des sciences et belles-lettres de Caen*, n.s. 1941, vol. 10, pp 245-337.

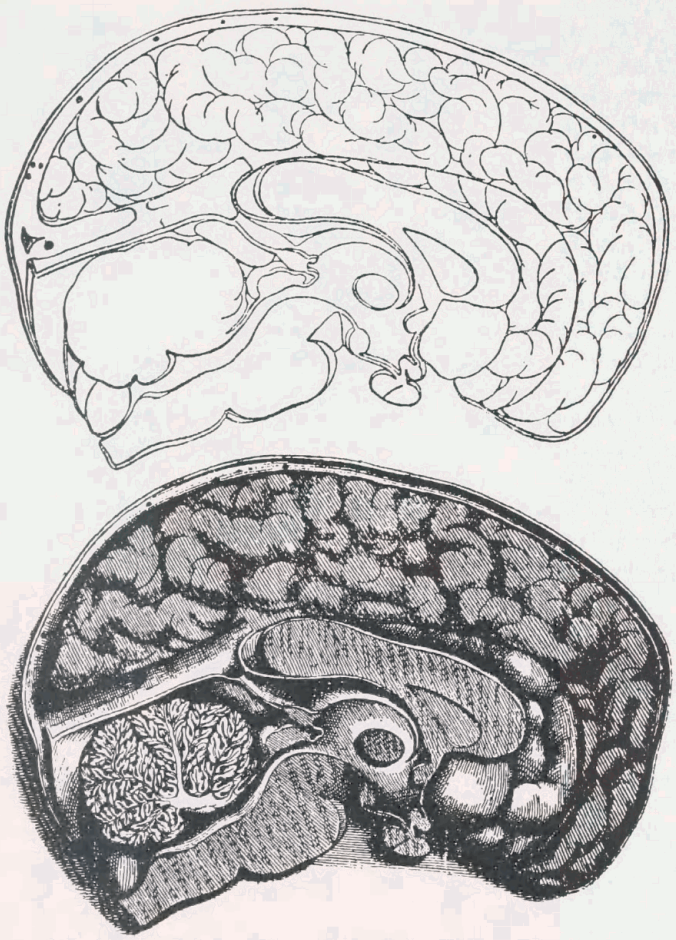


Fig. 5. Plate illustrating midline section of human brain from the *Discours sur l'anatomie du cerveau.* Presented as a lecture at Paris in 1665, printed in 1669.

ferent drugs externally, by mixing them with food or by injections in the vessels, and to learn from that, what disturbs the animal actions and what is the most appropriate remedy when they are disturbed".[85] Except for the illustrations (Fig. 5), which are remarkably exact and detailed in spite of being based on the study of unfixed brain-tissue, the *Discours* contains little "textbook" anatomical information.

Summarizing all major positions of Stensen, no later review matches that one given in the year of publication in the *Transactions of the Royal Society* for 20 September, 1669:[86]

85. *Lecture on the anatomy of the brain*, p 152. See also Divac, 1986.

86. *Philosophical Transactions*, 1669, vol.5, pp 1034-37. The reviewer's identity is not revealed by the minutes of the Royal Society, since there is a gap from 22 July to 11 October 1669 in Birch's edition.

In the beginning of this Discourse the Author represents, that those, who search after solid knowledge, will find nothing satisfactory in all that hath been hitherto written concerning the *Brain*: that all, which Anatomists agree in, is only, that it consists of two Substances, a White and a Grayish, and that the *former* is continued with the Nerves, that are distributed through the whole Body; and the *latter* serves in some places for a kind of *Cortex* to the *White*, and in others, severs the white filaments from one another. But that they are yet ignorant, what those substances are; in what manner the Nerves are Joyned in the *White*; and how farr their extreamities advance in it; from which disposition yet depends all the diversity and variety of our sensations and motions. And as for the *Ventricles* or Cavities of the Brain, he affirmes them to
<p 1035> be no less unknown, than its Substance; some Anatomists lodging in them the Spirits, others making them the receptacles of the Excrements of the Brain; and both perplext in assigning the source and Issue of the Excrements, and the Spirits, and the manner of the production of the latter.

Besides this, he finds a great defect in the way of dissecting the Brain, and having shewed the imperfection in the common ways, he proposes and recommends that (though difficult one) of continuing the filaments or threads of the Nerves through the Substance of the Brain, to see, where they pass, and where they terminate.

Next, he entertains the Reader with an Enumeration of the chief *Errors* of Anatomists touching the brain. And here he examins particularly the Systemes of Dr *Willis* and Monsieur *Des Cartes*. In the *former* he takes special notice, that the Author thereof lodges the *Common Sense* in the *corpus Striatum*; the *Imagination* in the *Corpus Callosum*; and the *Memory* in the *Grayish Substance* which encompasses the *White*. But then he declares, that these assertions are very obnoxious; for, whereas Dr *Willis* describes that *Corpus Striatum*, as if there mere[were] two sorts of Streaks or Rays, some ascending, some descending, he finds, that a separation being made of the *Gray* body from the *White*, those Rays will be found to be all of the same nature, that is, they make part of the *White* substance of the *Corpus Callosum* which passes towards the Marrow of the Back, separated in divers Layers by the intervening of the *Grayish* Substance. Which being so, *saith he*, with what certainty can be made to believe, that those three Operations are performed in those three Bodies: And who can tell us, whether the nervous Fibres have their beginning in the *Streaked Body*, or whether they rather pass through the *Callous Body* into the *Gray Substance*.

In the *latter* of M. *Des Cartes*, he finds, that that Philosopher hath rather *devised*, in his *Treatise of Man*, such an Engine, that performs all the actions, Men are capable of, than described Man, as *really* he is; which he undertaketh to prove by divers instances, taken from the *Cartesian* fabrick of the parts of the Brain: in the doing of which our Author showes great dexterity, skill and accuratenes. And from hence he proceeds, to observe the want of exactness in the Cutts or *Figures*, hitherto given of
<p 1036> the Brain: and although he acknowledgeth, that the best Figures, hitherto made of that part, are those of Dr *Willis*, yet he finds several faults committed here and there, and conceives, there are many things to be added for making them perfect: which certainly this able Anatomist will consider further, and according to his Ingenuity, as he shall see cause, rectify, if the Author of the Book, reflected on, prevent him not.

Having thus discussed the hitherto practiced way of dissecting the Brain, and the litle light to be derived thence, together with the defectiveness of the Figures belonging thereto, *he leaveth it to the Consideration of Judicious men, what faith is to be given to the Explications made upon such unsolid foundations*; and that done, he declares, which are the two only ways for attaining the true Knowledge of an Engine; *viz. One*, by having the contrivance of it discovered by the Author himself; the *other*, by taking it in pieces to the very least parts, and examining them all both severally and joyntly.

The former not being to be expected, he excites the Lovers of real knowledge to the careful performance of the latter; excusing in the mean time those two sorts of persons, that hitherto have addicted themselves to Anatomical researches, *viz. Physitians* and *Chirurgions*, for not having made satisfactory discoveries by their labors, and alleadging on their behalf their want of time requisite for this purpose; the ill consequence of which he represents to be, that they often undertake to cure a Body, of which they know not the Structure, which is no better, (saith he) then if a man would repair or wind up an Engin, the parts of which he is ignorant of. And as for Professors of Universities or other Schools, he Judges them not so proper for that particular application, and the variety of methods of dissecting; both which is necessary for examining every the smallest part, and the observeables thereof; there being sometimes required whole years for finding out one onely thing, that perhaps may afterwards be demonstrated to others in one hour; which he exemplifyes by divers instances of Discoveries, made by some of the modern anatomists.

He concludes his Discourse by recommending the method which seems best and most convincing to him, for making true Discoveries in Anatomy; where he adviseth, that for obtaining the true history of the parts, we should examine and accordingly draw them in that State, in which they are found naturally, without at all forcing them, thereby to find, whether the parts are indeed joyned together or separated, and what situation is assigned them by Nature it self. Where he desires, that the Anatomist would not only be intent upon the part, on which he is for the present employed, but also reflect upon all the Operations, he hath made before he came to that part, which may have caused some change or other in the same, as to its scituation, connexion *&c.* Of which he also alledges divers Examples, especialy as to the Brain. <p 1037>

Besides this exact attention on all the Operations, he further counsels the Change of the *ways* of Dissecting, and deduceth the ill consequences of binding ourselves to certain fixt Laws of dissecting each part; this benefit resulting from that Change, that if it doth not always discover something new, it lets us know at least, whether we have been deceived in what we have seen formerly, especially in things dubious and contested. Of the necessity of this Change he brings manifest proofs; and having done so, he alledges the reason why he says nothing of the *Use* of the parts of the Brain, nor of the actions called *Animal*; it being impossible to explain the motions, that are made by an Engin, if the artifice of the parts be not known, and those Anatomists rendring themselves ridiculous, that discourse so magisterially of the Use of the parts, of which they know not the structure.

Last of all, he observes, that when all this, he hath discoursed of, *is* done, that is but the least of what is *to be* done; in regard that for the acquiring of some good Knowledge of the Brain, there must be Dissections and Examinations made of as many Heads, as there are different species's of Animals, and different States and Conditions of each kind; since that in the *fetus's* of Animals it will be seen, How the Brain is formed; and what could not be seen in sound and entire Brains, may be seen in such, as have been changed by sickness.

In a sentence emphasized here by me, the reviewer in the *Transactions of the Royal Society* stressed how Descartes's and Willis's theories were made on "unsolid foundations". In spite of Stensen's well communicated and well reviewed warning, the figments of imagination in Descartes became the structural basis of theories, and speculation became the method shared by scholars pondering the biological foundation of thinking and Descartes's mind/body dualism. These efforts are per-

petuated by most historical commentators. This example epitomizes how immune a paradigm can be against criticism: with few exceptions mentioned below, historians of science do not remark that, seven years after its publication, the hydraulic brain in Descartes's *Treatise of Man* was deflated, and that the physiological foundation for ventricular psychology, the rotating pineal body, was reduced to a myth in public. Stensen's sound advice on how properly to investigate the brain by such a simple method as to trace the nerve tracts through the brain is mostly ignored.

A short review by the *Journal des sçavans* on 10 February, 1670 emphasized Stensen's point that anatomists, who were wont to use such terms as *nates, testes, anus, vulva, penis* to denote different structures of the brain, showed that they did not know either the usage or the shape of those structures. Stensen had less success when he renamed the pituitary gland as the lower gland to avoid association to production of slime of the nose [*pituita* slime, phlegem, rheum]. The French reviewer avoided a definite choice between Descartes's and Stensen's description of the brain.[87] In 1770, Portal declared that the *Discours* "is loaded with useful views on anatomical practice containing the most safe ways to proceed in the research of truth. Moreover, Stensen proposes opinions with such modesty and simplicity that fully he merits Haller's words of praise: *vir industrius, candidus, innocuus & magnus inventor.*[88] As was remarked by Max Neuburger in 1897, in the *Discours* "Steno provided a *tabula rasa*, which in a negative way led to so much that was positive and absolutely necessary in order to pave the way for progress." However, the first author to penetrate Stensen's contribution to the core was the French philosopher A. Georges-Berthier who, in 1914, in an analysis of Cartesian physiology, wrote:[89]

---

87. *Journal des Sçavans* 1670, pp 7-9. *Cf.* the Amsterdam edition 1679, p 585-87. An Italian translation of the French review was brought by *Giornale de'Letterati*, Rome 1670, p 39-40.

    Ce qu'en a écrit M. Descartes dans le Traité qu'il a fait de l'*Homme*, est beaucoup plus ingenieux; mais il n'est pas plus veritable, si l'on en croit ce Discours. Car l'Auteur soûtient qu'il s'en faut beaucoup, que l'Homme de M. Descartes ne soit fait comme les autres Hommes; & particulierement en ce qui regarde le Cerveau, il montre que la glande pineale est autrement située que n'a dit M. Des-cartes; que les vaisseaux qui l'environnent, sont des veines & non pas des artéres; & que cette glande est tellement engagée dans le Cerveau, & si bien attachée, qu'elle ne sçauroit pancher de costé ny d'autre. Mais la beauté de l'invention cache les erreurs de l'hypothese, & ces fautes sont si ingenieuses qu'il est glorieux à M. Descartes de les avoir faites.

88. Portal, 1770, III, p 178, with reference to Haller, *Meth stud*, p 521.

89. *Isis*, vol. 2, pp 71 and 73. In 1914, at the age of twenty-seven, A. Georges-Berthier died in combat. The translator of *Treatise of Man*, Thomas Steele Hall, characterized Georges-Berthier as "he who until very recently had done the best scholarly work on Cartesian biology".

> Stenon, le plus grand, après Harvey, et le plus lucide génie physiologique du XVIIe siècle, qui fit à Paris en 1669 une critique de l'hypothèse cartésienne à laquelle il n'y aurait aujourd'hui encore rien d'important à opposer.
>
> Encore aussi que Stenon ait dénoncé, avec une admirable pénétration, l'arbitraire de la conception cartésienne.

In 1969, at the third centenary of the publication of the *Discours*, neuroscientists and medical historians gathered at Copenhagen for a conference, the scholarly proceedings of which discussed its biological aspects.[90] In 1991 Renato G. Mazzolini innovatively made Stensen the key person in a review, "Schemes and models of the thinking machine: From Descartes to Haller".

Overt criticism of Descartes made Stensen's lecture highly controversial in Paris in 1665, with scientists divided into factions, the *Gassendists* adopting empiricism and the atomism of Democritus and Epicurus, and critical against the metaphysics and rationalism of the emergent *Cartesian* faction. In a losing game, Stensen was used by friends who were mainly among the still dominant *Gassendists*, in this *grande bataille philosophique*.[91] As remarked by Mazzolini "in the struggle for philosophical hegemony, Steno's arguments thus came to be directed against the followers of Descartes both by the Sorbonne and by the school of thought that was centred on Pierre Gassendi".[92]

At the same time, Paris was also riven by religious disputes: Catholics against Huguenots, and within the Catholic community, the *Jansenist* conflict. According to Scherz, Stensen no doubt took part in religious discussions. In his writings he later recalled the influence from his conversations with Countess Hedevig Margarete Elisabeth von Rantzau[93] on the Eucharist, and with Marie Perriquet, the cousin of Thévenot.[94] In later letters he distanced himself from *Jansenism*.[95]

The *Discours* was the only scientific work by Stensen published in a modern language.[96] In 1671, it was translated into Latin. In 1732, the

---

90. *The historical aspects of brain research in the 17th century*, G. Scherz (ed.), 1968.
91. Schiller & Théodoridès, 1968, p 162, has quoted a letter from Chapelain to Huët, 6 April 1665:

    > Mr Sténon danois, a fait dans cet art les plus belles épreuves qu'on ait encores veuës, jusqu'à forcer les descartistes, ces dogmatiques si opiniastres, à tomber d'accord de l'erreur de leur patriarche pour la glandule du cerveau et pour son usages.

92. Mazzolini, 1992, p 68.
93. *OTH*, I, p 191.
94. *E* 146. Cf. Scherz, *Nicolaus Steno and his Indice*, p 24.
95. *E* 126 and 127.
96. In *De solido* Stensen mentions that he had intended to write this work in Italian.

work again received attention when Jacques-Bénigne Winslow (1669-1760), professor of anatomy at Paris, a great-nephew of Stensen[97] and like him a Catholic convert, reprinted the lecture in his text-book on anatomy,[98] although without its fine illustrations. Winslow's work was published in ten French editions up to 1776, and with that text-book, the *Discours* was translated into German, English, and Italian, and in this century into Danish and Dutch.[99]

From Stensen's stay in Paris also came a pathological-anatomical study of a stillborn baby with multiple congenital defects, including those malformations of the heart, *OPH* 20, described again in 1888 by Antoine Fallot and rightly termed the tetralogy of Fallot.[100] Stensen described the structural defects including the overriding aorta, pulmonary stenosis and the ventricular septal defect, and he explained the presumed abnormality of the fetal circulation.

In the autumn of 1665 Stensen left Paris, travelling south through France. At Saumur he met the Cartesian philosopher and illustrator for the first French edition in 1664 of *Treatise of Man*, Louis de La Forge.[101] At Montpellier, where Stensen spent some months, he met some travelling English scientists, among whom was William Croone, who had published anonymously a book on muscle contraction, *De ratione musculorum*, the year before in London. There is evidence that Stensen and Croone not only discussed theories of muscle contraction but that Stensen also demonstrated his newly detected muscle structure by dissections. Another Englishman, Martin Lister (1638-1711) wrote:[102]

> I had ye great honour to assist att an Anatomie Lecteur or some particular dissections made by Mr Steno ye Dane himselfe in my Lord of Ailesburys cabinet. The Demonstrations were neat & clever wherein I much admired ye ingenuity & great modestie of ye Person & wch appeared the rathar, by reason of ye great impertinencie of a French Docteur yt assisted alsoe at ye Assemblé.
>
> Afterwards I visited Mr Steno, whom I found infinitely taking & aggreable in conversation & I observed in him very much of ye Galant & honest man as ye french say, as well as ye schollar ... Moreover he shewed us yt the make of muscles was not as ye Ancients phansied, yt is, ye Fibers lay not in a straight line from Tendon to Tendon, but made alternate Angles wth ye two Tendons, etc.

---

97. Winslow's great-grandfather Claus Pedersen was a brother of Niels Stensen's father, Sten Pedersen.
98. In the preface, Winslow mentioned his inspiration from Stensen: "que le seul Discours de feu M. Stenon sur l'Anatomie du Cerveau, a été la source primitive & le modele general de toute ma conduite dans les travaux Anatomique."
99. Rafaelsen, 1986. Dutch translation, see Vugs.
100. Willius, 1948.
101. *Biography*, I, p 140. Cf. Hall's notes on de La Forge in *Treatise of man*, p XLI.
102. Oxford, Bodleian Library, Lister MS 5, fol. 224v-226r. Cf. Scherz, 1956, *Vom Wege*, p 230.

Philip Skippon, another scientist from the British group, reported:[103]

> Monsieur *Steno*, a *Dane* was at this time in *Montpelier*, and he is very happy in some anatomical discoveries, *viz.* the *Ductus Salivaris* from the *Parotides* to the middle of the cheek: We were present at his dissection of an ox's head, and observed a blade of grass that was forced up that *Ductus*: In a man the *Ductus lies streight*, but in a beast oblique.

The meeting at Montpellier was to have impact in the field of muscular mechanics. Yet another matter may have been touched upon: the problem of the organic or non-organic origin of fossils. Like two of the Englishmen he met, Martin Lister and John Ray (1627-1705), Stensen later made contributions on geological issues and fossils. Fossils had recently been treated by Robert Hooke in *Micrographia*, a book circulating in Paris by early 1665. No records of any discussions have survived, but the fact remains that, in November/December 1665 at Montpellier, the three men who were to make the greatest contributions to paleontology in the years to come met one another.

By January 1666, all Englishmen were ordered out of France for reasons of security. Stensen was given a call in a letter by Chapelain to return for the winter to Paris (*E* 18), but he continued on to Florence and never did return to France.

1.7 Scientist to the Medici Court at Florence

In March 1666, Stensen arrived at the Tuscan court's winter residence in Pisa. He was very well received by the Grand Duke and became attached to the court as a scientist with residence in Florence. In May and June 1666, Stensen also visited Rome where he met and developed a lasting friendship with the great microscopist, Marcello Malpighi (1628-1694).[104]

Ferdinand II (1610-1670), Grand Duke of Tuscany, and his brother, Leopold de Medici (1617-1675), were both highly interested in science. In the Pitti Palace at Florence, they had organized a scientific academy in 1657, the *Accademia del Cimento*, or Academy of Experiments, which included among its members, the mathematician and last surviving pupil of Galileo, Vincenzo Viviani (1622-1703), the physician and naturalist, Francesco Redi (1626-1697), and Lorenzo Magalotti (1637-1712), secretary of the academy and publisher of its proceedings, the *Saggi*, or Essays on natural experiments, commented by Stensen,

---

103. Cf. Poynter, 1968, p 274.

104. *E* 45, 55, 56, 65, 67 and 106. I have looked in vain for comments by Malpighi on Stensen's works on muscle.

E 33. Another member was Giovanni Alfonso Borelli (1608-1679), professor of mathematics in the chair formerly occupied by Galileo at the University of Pisa.[105]

The academy did not have a long life span – it held its last meeting in March 1667, shortly after Leopold de Medici became a cardinal. There was a polarization between supporters of the two mathematicians, Viviani and Borelli, that may have contributed to the final break up of the academy, and most certainly to Borelli's abrupt departure in 1667.[106]

Borelli's major interest was the study of animal movements, and, at the time of Stensen's arrival, he had already written the greater part of his work, *De motu animalium*, which was published posthumously in two volumes, 1680-81. In a letter of 17 July, 1666, Borelli wrote to Malpighi that Stensen had arrived at Florence, where he was expected to remain all summer.[107] Stensen, Borelli continued, wanted from him instruction on some things about geometry; and although Borelli planned to be courteous, he did not regard Stensen as highly as they did at the palace, and he expressed suspicion of Stensen's motives.

An earlier letter indicates that Stensen may have been the subject of Borelli's suspicion even before his arrival, when the latter learned of the priority dispute between Stensen and Blaes. In a letter to Malpighi (10 July, 1665[108]), Borelli referred to a pamphlet by Anton Deusing, one of Blaes's supporters, in which Deusing stated flatly that Stensen had stolen this discovery from Blaes. While Borelli and Stensen shared an interest in geometry and the study of muscular mechanics, Borelli's notably quarrelsome character,[109] together with his knowledge of Deusing's version of the dispute at Amsterdam seems to have prevented any research partnership.[110]

---

105. Bonelli, 1968.
106. Biagi & Basile, 1980, pp 373 ff.
107. Adelman, 1975, letter 167.
108. *ibid,* letter 134: "in un libretto del Deusingio, che riferisce l'invenzione dei vasi salivali esser' del detto Blasio, e che fu rubato dallo Stenone".
109. Magalotti, in a letter 6 January 1668 to Grand Prince Leopold, made the following characterisation: "Borelli was such a tiresome person that I would almost have called him intolerable." Cf. Biagi & Basile, 1980 p 377.
110. In 1968 Maria L. Bonelli wrote (p 257): "Of course, Borelli could not bear having Stensen as a rival in the studies of myology as he considered himself the first amongst all." She continued with an excerpt from an inedited letter ascribed to Stensen, a letter of potential importance for the relation between Stensen and Borelli. However, Professor Leonardo Negri, Leghorn, has not been able to verify the authenticity of such a letter written by Stensen. All files of Maria Bonelli, the late Director of *Istituto e Museo di Storia della Scienza* of Florence, were destroyed before she left office.

The *Elementorum myologiæ specimen* is a work incompatible with the ideas on muscle contraction expressed by Borelli. There can be no doubt that the conflicting issues were discussed by the two scientists. In the letter to Thévenot, appended to the *Elementorum*, Stensen responded harshly to vigorous attacks on his ideas on muscle contraction by anonymous adversaries. I have been unable to find competent opponents to Stensen other than Borelli who could have aroused such bitter reactions.[111]

Like the conflict over the glands, the one on muscles seems not to have diminished Stensen's working capacity; it may even have stimulated it. Within a half year of his arrival in Tuscany, he finished, and within another half year, published the major work on muscles, the *Elementorum myologiæ specimen*. It is a book containing a detailed geometrical description of muscular structure and contraction with numerous illustrations.

Stensen described the contraction of equally long motor fibres, arranged as uni- or multipennate structures, each forming a parallelepiped between parallel tendon plates. Stensen used the parallelepiped as a model, allowing him to apply mathematical methods: when the motor fibres contract, the tendons move in parallel planes and the muscle shortens, but the distance between the tendon planes does not change. There will appear a swelling, even if the volume of the model remains the same. Therefore, the swelling observed during contraction of muscles, according to Stensen, is no argument for an increase in muscle bulk and no argument against contraction without any change of muscle volume. In the *Elementorum myologiæ specimen* Stensen did away with the supernatural animal spirits as a driving force making the muscles swell and contract. In this respect the work is a clear continuation of the *Discours sur l'anatomie du cerveau*. Whether by coincidence or not, in the middle of June 1667, a few months after the *Elementorum myologiæ specimen* had been published, Borelli left Tuscany with the manuscript of his version of muscular motion and resigning his professorship at Pisa for a far less distinguished chair at Messina.

The reception of the *Elementorum* was indeed promising from the beginning. Within one year after its publication there was a long and fair review, probably by Croone, in the *Philosophical Transactions of the Royal Society*. Illustrations of Stensen's theory with favourable comments were given in works from 1669 by Lower, and in 1670 by Willis in London who quoted Stensen seven times without mentioning any other reference. Stensen's plate I on the architecture of muscles

111. Kardel, 1990.

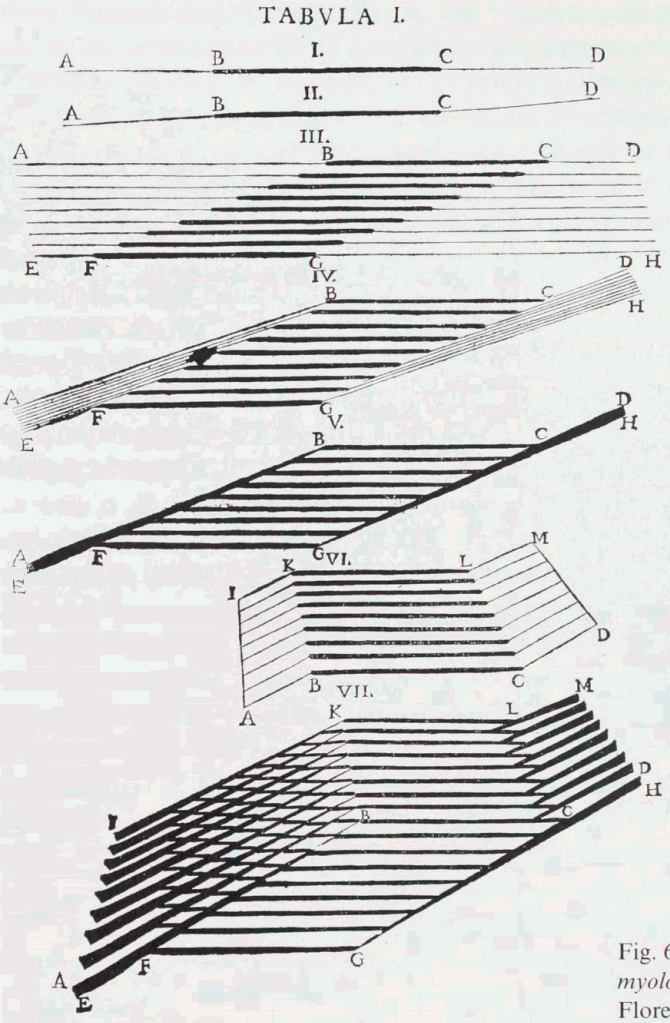


Fig. 6. From *Elementorum myologiæ specimen*, Florence 1667.

(Fig. 6) was admitted in the 1677 Lyon-edition of Bartholin's Anatomy. Soon, however, followed devastating critical publications dealing with Stensen's theory: in 1674 by Mayow from Oxford, in 1680 by Borelli in Rome, in 1694 by Johann Bernoulli at Basel, in 1743 by Boerhaave (posthumously) from Leiden, and in 1762 by Haller in Switzerland. Although today, these criticisms appear irrelevant, erroneous, and without scientific foundation,[112] by the end of the eighteenth century Stensen's theory had all but disappeared from the scientific literature. Since 1980, anatomical and biomechanical reports from several scientific centres in the Netherlands and the United States have shown that

112. *ibid.* Steno on Muscles.

the anatomical foundation and the theoretical as well as practical applicability of Stensen's theory are valid. Thus, while considered by Maar to be perhaps Stensen's weakest work, the *Elementorum myologiæ specimen* may be one of Stensen's more significant publications, and it is now considered to be a significant work in the biomechanical science.[113] Once again is emphasized as a touch-stone in the scientific process, comparisons.

Stensen attached to the *Elementorum myologiæ specimen* two treatises describing dissection of sharks. In one, the *Canis carchariæ dissectum caput*,[114] he described a gigantic 3,500 pound *Carcharodon rondeletii*, caught near Leghorn on around 20 October, 1666. Its head had been given to him for dissection. The impressive speed with which Stensen completed this work indicates the generous support provided him by the Grand Duke, to whom the work is dedicated. The book was probably in circulation late in April 1667, and as mentioned it was reviewed early in 1668 in the *Philosophical Transactions of the Royal Society*, and, in 1669, by the Rome Academy.

When describing the huge shark, Stensen made a detailed comparison of the teeth of the shark with the so-called tongue stones found in great numbers in the rocks of Malta, and he concluded:

> Thus since the bodies resembling parts of animals that are dug from the ground can be considered to be parts of animals, since the shape of tongue stones resembles the teeth of a shark as one egg resembles another, since neither their number nor their position in the earth argues against it, it seems to me that those who assert that large tongue stones are the teeth of a shark are not far from the truth.[115]

Built upon investigations, *historia*, the theory on the formation of fossils is formulated in six "conjectures", each one examined as if to provoke contradictions[116]:

(1) That soil from which bodies resembling parts of animals are dug does not produce these bodies today.

---

113. Referring to Stensen' myology, Professor Peter A. Huijing, Ph.D., Amsterdam, writes in the *Encyclopedia of Sports Medicine*, London 1991, p 139: "As early as the seventeenth century, some workers in the field of muscle morphology were aware of these phenomena but such information was not widespread and disappeared from the current body of knowledge until very recently". It is not quite correct that information was not widespread. At least six eminent scientists discussed and finally rejected Stensen's theory. See *Steno on Muscles*.
114. *GP*, pp 65-131 (with English translation).
115. *GP*, p 115. Several authors from that period described the tongue stones, among them Thomas Bartholin and his predecessor, Ole Worm.
116. Noe-Nygaard, p 177.

(2) The said soil does not seem to have been firm when the bodies referred to were produced in it.
(3) Nor can there be strong opposition to the belief that the said soil was once covered with water.
(4) There seems also to be no objection to the belief that the said soil was at some time in the past mixed with water.
(5) I cannot see anything to prevent us from regarding the said soil as a sediment gradually accumulated from the water.

Building on the previous conjectures, the main thesis is:

(6) There seems to be no objection to the opinion that bodies dug from the ground which resemble parts of animals should be considered to have been parts of animals.

The *Canis carchariæ* is today a classic work in paleontology as well as in geology.[117] In its style the *Canis carchariæ* has elements typical of the baroque period. Like a piece of seventeenth-century music or architecture, it is loaded with details each one of which may be studied separately or as parts of a whole. One such detail is the so-called Stensen-experiment described in a short paragraph:

> I might have used another argument to call in question the hitherto accepted function of the brain, for I have observed, on making a ligature in the descending aorta, without previous cutting, that voluntary movement of all parts below ceased in proportion to the tightness of the band, while it was restored similarly as the knot was loosened. I have made such observations for several years and have demonstrated them in various places,[118] particularly in Florence, where the dog survived without suffering any damage to its mobility, after the ligature was removed. Since this experiment requires completion by other methods, as yet untried, I shall add nothing more about it here (*GP*, p 89).

Stensen wrote no more than that, but the issue was found so important by members of the Royal Society of London that, as soon as the *Elementorum* was received on 6 February 1668, successive investigators, made repeated attempts to reproduce the experiment. Since they used an open approach to the aorta, their efforts were in vain. Stensen had used, as he revealed in correspondence,[119] a large curved needle with

117. Garboe, 1958. Scherz (ed.) 1971. Rudwick, 1972. Noe-Nygaard, 1986.
118. The experiment was seen in Paris by Ole Borch, as mentioned in his *Itinerary* on 3 March, 1665.

a ligature, which was passed percutaneously in front of the aorta and the vertebral column. Then the ligature was tied behind the animal's back, hereby compressing the aorta against the vertebræ. As expressed by Poynter: "Steno's scientific integrity and accuracy were being put to the test by the chief scientific body in Europe and the care that was eventually taken to ensure that justice was done reflects as well on the Royal Society as it does on Steno."[120]

The experiment demonstrated, it was presumed, the necessity of blood supply for the muscles to contract. It is evident that members of the Royal Society showed much greater attention to this brief account of an experiment than to Stensen's main proposition on muscular action. It is too simple to say that the British scientist went for experimental data rather than for geometrical analysis, since at that time both areas attracted their interest in other fields. My suggestion is that the British scientists were looking for the crucial experiment to reveal the source of the material filling the muscles when expanding during contraction. If this is the case, however, they would have looked in vain. Both Willis and Swammerdam[121] made notes on ischaemia of the spinal cord as a possible factor in Stensen's experiment. Eventually, two German theses, by J. Schiffer in 1869 and by A. Weil in 1873, conclusively showed that the experiment had described limb paralysis due to ischaemia of the spinal cord and not due to muscle ischaemia.[122]

In the smaller second appended description of a shark-dissection, the *Historia dissecti piscis ex canum genere*, *OPH* 24, Stensen con-

---

119. "Mr Oldenburg read a letter to him dated Paris June 6, from Signor MAGALOTTI, containing Mr STENO's method of making the experiment of depriving a dog of all sense and motion, without depriving him of life" *History of the Royal Society of London*, II, p 293. Se also letter from Magalotti in Paris to Oldenburg, 6 June, 1668 (Hall & Hall, 1965), with excerpts from a non-extant letter by Stensen dated 18 May, 1668. Cf. Scherz, "Neue Stensenbriefe". Stensen's experiment was mentioned at meetings of the Royal Society on February 13, 27; March 5, 12, 19; April 2; June 4, 11, 18, 25; and July 2. The following members of the Royal Society were involved in discussing or reproducing the experiment: Oldenburg, Croone, Lower, Clarke, Hooke, and King. Finally, at the meeting on July 16, 1668 it was recorded: "The experiment of Mr STENO was tried, according to his method, before the society by Dr King, and succeeded, so as the dog, upon whom it was made, was seen to be deprived of all motion below the part, where the descending artery was tied, which was upon the top of the spine by a needle passed through between the 8th and 9th ribs."
120. Poynter, 1968, p 276.
121. *Biblia naturae* was not published until long after Swammerdam's death by Boerhaave. Swammerdam probably carried out the work in the late 1660's. Cf. Lindeboom, 1975, p 286.
122. Faller, 1985.

tinued in a dogfish the studies of female reproductive organs initiated in 1664 by the dissection of a ray-fish, *OPH* 16. Stensen stated for the first time that the so-called female testicles, *testes mulierum*, in a non-oviparous animal, a *Scymnus Lychia* dogfish,[123] were analogous to the ovaria of oviparous animals and ought to be called by that name. This work was also reviewed in the *Transactions of the Royal Society*, 1667, vol. 2, p 628:

> The *other* Narrative is of a Female *Dog-Fish*, dissected also by himself, where do occur no less remarkable observations than in the former, both of the parts in the Head, and of those in the Body; as touching the small weight of the Brain of this Fish, compared to the weight of its Body; several *little Fishes* found in the Stomach, untouched by any Teeth; the *Ureters*, the *Ovarium*, and *Oviductus*, where he digresses, to shew, *Mulierum testes Ovario analogos*, and refers, for further proof of this to his intended Treatise, which is to give an account *de partium Genitalium Analogia*.

Previously, ovaries in mammals as well as in women were considered to be rudimentary testicles.[124] Stensen was the first to have reached another conclusion.[125]

Following the publication of these works in 1667, Stensen continued his investigation of female reproductive organs by dissections of different mammals and five female corpses, Fig. 7. The results were, however, not published until 1675,[126] three years after similar observations had been published by his former teacher at Leiden, van Horne, and his friends, Swammerdam and de Graaf.[127] Swammerdam and de Graaf ended up in a bitter dispute on priority. This dispute was referred to the judgment of the Royal Society of London. In their answer, reported on 7 May 1673, Croone, Needham and King accepted neither Swammerdam, nor de Graaf, but Stensen to be the first to discover the mammalian ovarian follicle.[128] Stensen remained on friendly terms with both de Graaf and Swammerdam, and already in a letter to Swammerdam from Leghorn dated 18 March, 1668, expressed his indifference as to the question of priority:

---

123. Lesky, 1968, p 239.
124. In *Dubia anatomica de lacteis thoracis*, 1653, Thomas Bartholin described, as if surprised, that "testicles" of a female body was in no way surpassed by those in men. It may have been a comment like this that aroused Stensen's attention.
125. Lesky, 1968, pp 240 ff. Poynter, 1968, p 279. Lindeboom, 1975, p 288.
126. *OPH*, nos. 25 and 26. For Stensen's definitions, see *OPH*, II: 25, p 159.
127. De Graaf, 1672. Swammerdam, 1672. In his treatise de Graaf compared his findings with those of "Clariss. D. N. Stenonis", p 183.
128. Poynter, 1968, p 279. The answer (in Latin) is found in T. Birch *The history of the Royal Society of London*, vol. 3, pp 102-07.

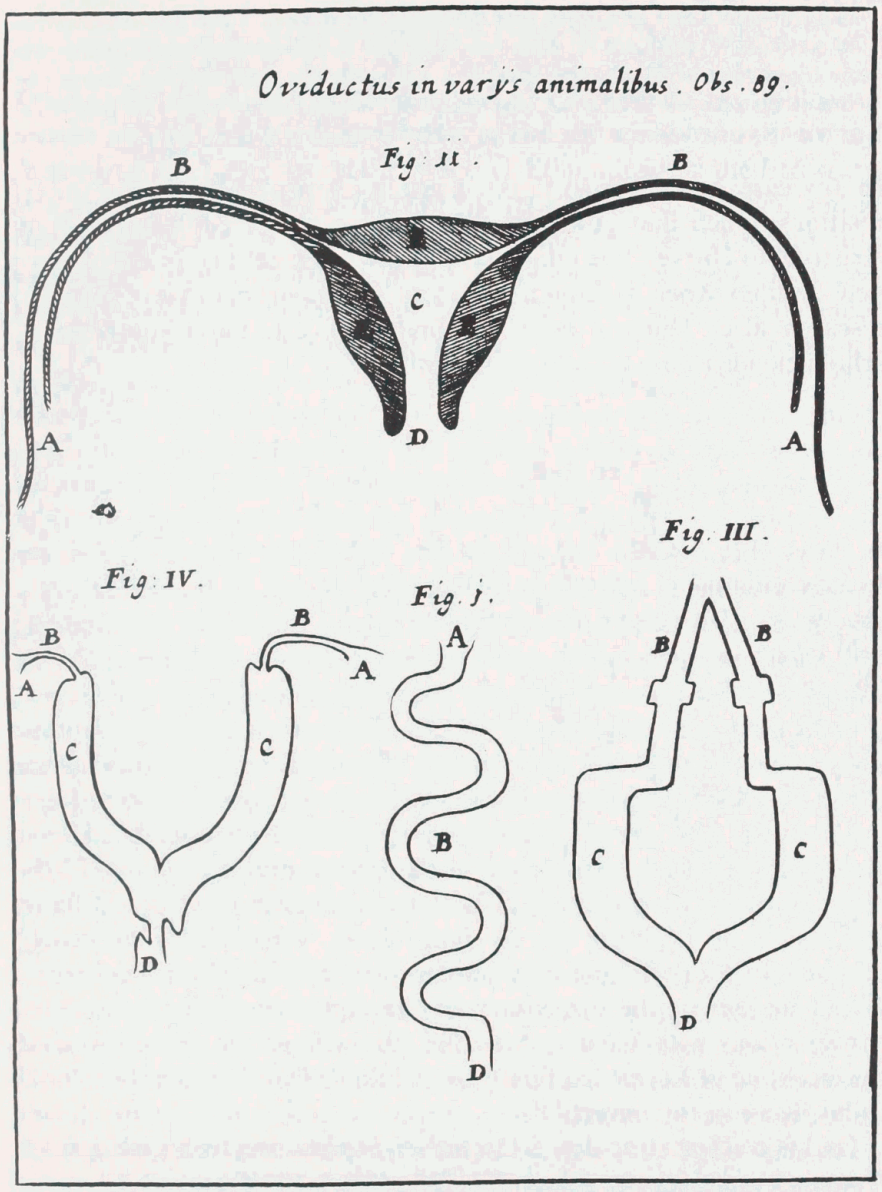


Fig. 7. The female internal genital tract in four species: I. Hen. II. Woman. III. Smooth shark. IV. Wolf. *Acta Med & Phil Hafn.* 1673 (printed 1675), vol. II, pp 219-32.

> In great expectancy I look forward to the famed van Horne's[129] and your observations on *testiculis,*[130] and I am far from resenting that in this question my preceptor and my friend forestalled me; even sacredly I will make this testimony that had in due time it been known to me, not only had I mentioned him by name but had made public his observations at the same place as my own (*E* 35).

In any case, according to Lesky, Stensen eliminated the fictive causal relations which had governed the development of embryology from Aristotle to Harvey. She adds that it is not sufficient just to list positive new findings when making a record of the progress in embryological research after Harvey; negative "findings", e.g. the elimination of scholastic ideas, are no less significant.[131]

1.8 Conversion

In November 1667, in the middle of a very active period in research, Stensen became a convert to Catholicism. Although he came from a deeply religious family in orthodox Lutheran Denmark, situations he had faced and persons he had met had led to a religious crisis. In the Netherlands, several churches coexisted with a majority Calvinist church, and even that church was divided into competing factions. Each church claimed for its members an eternal truth. Acquaintance with Catholics, among whom were his fellow students at Leiden, Reinier de Graaf and Theodor Kerckring (1639-1693), had made Stensen change his childhood perception of the lack of morality among Catholics. Shortly after his arrival in Tuscany, he attended a Corpus Christi procession in Leghorn on 24 June, 1666, which left him deeply touched. In Florence, the spontaneous piety of Sister Maria del Nero, whom he met at the dispensary of the Annalena Convent, and his conversations with Lavinia Arnolfini, the wife of the ambassador of the city state of Lucca, led finally on All Souls Day, 2 November, 1667, to his decision to convert.[132]

On his confirmation day, 8 December, Stensen received a letter from Denmark in which the King, Frederik III, ordered him to return to Copenhagen, offering a pension of 400 Taler per year. Realising that his conversion might alienate Lutheran Denmark, he responded by asking whether the order was still in effect despite his Catholicism.

---

129. J. van Horne, *Prodromus de partibus generationis*, 1666.
130. "*testiculis*" meant testes as well as ovaries.
131. Lesky, 1968, p 248.
132. *E* 36. Scherz, *Nicolaus Steno and his Indice*, p 28.

1.9 Geological Research

During the following six months, Stensen continued his geological studies on the rich variety of geological formations in and around Tuscany: in the iron ores on the island of Elba mined by the Etruscans in antiquity, on the abrupt folds of the rock strata at Volterra, and in the marble district of Carrara.[133] He recorded the results hastily in a preliminary report *De solido intra solidum naturaliter contento dissertationis prodromus*, which was published the following year 1669 under the supervision by Viviani, after Stensen had left Florence to return to Denmark. In this *Prodromus*, Stensen departed from the belief that nature was created once and for all with mountains, oceans, plants, and animals. Fundamentally, the treatise presents a new system of classification for solids contained within solids – a classification by common origin, rather than by superficial similarity of outward appearance.

Stensen – and I adhere closely to the analyses by Stephen J. Gould and by Kurd von Bülow – used two criteria, well described already in the 1671 review of the *Philosophical Transactions of the Royal Society* (see below), for this subdivision. First, in what Gould calls the "principle of molding", Stensen argued that when one solid lies within another, which of them hardened first can be discovered by noting the impress of one object on the other. Thus, the shells press their form into the sediment surrounding them, while surrounding rocks were solid before calcite veins filled pre-existing channels. The principle of molding allows the establishment of a temporal order of formation for two objects in contact.

Stensen's second criterion is that of sufficient similarity. Past processes cannot be observed in principle; only their results remain. Clues to the processes of the past must be found in the objects themselves by detailed similarity in comparisons with products of processes observed directly today. Thus, Stensen argued, the sedimentary rocks must be the deposits of rivers, lakes, and oceans because they agree with those sediments that turbid water deposits today. Fossil shells once belonged to animals, and crystals precipitated from fluids as may be observed (Fig. 8). With these two principles – molding and sufficient similarity – Stensen established the requisites for geological reconstruction (and even for any other historic reconstruction): he could determine how and where objects were formed, and he could order the events in time.

---

133. Rodolico, 1971.

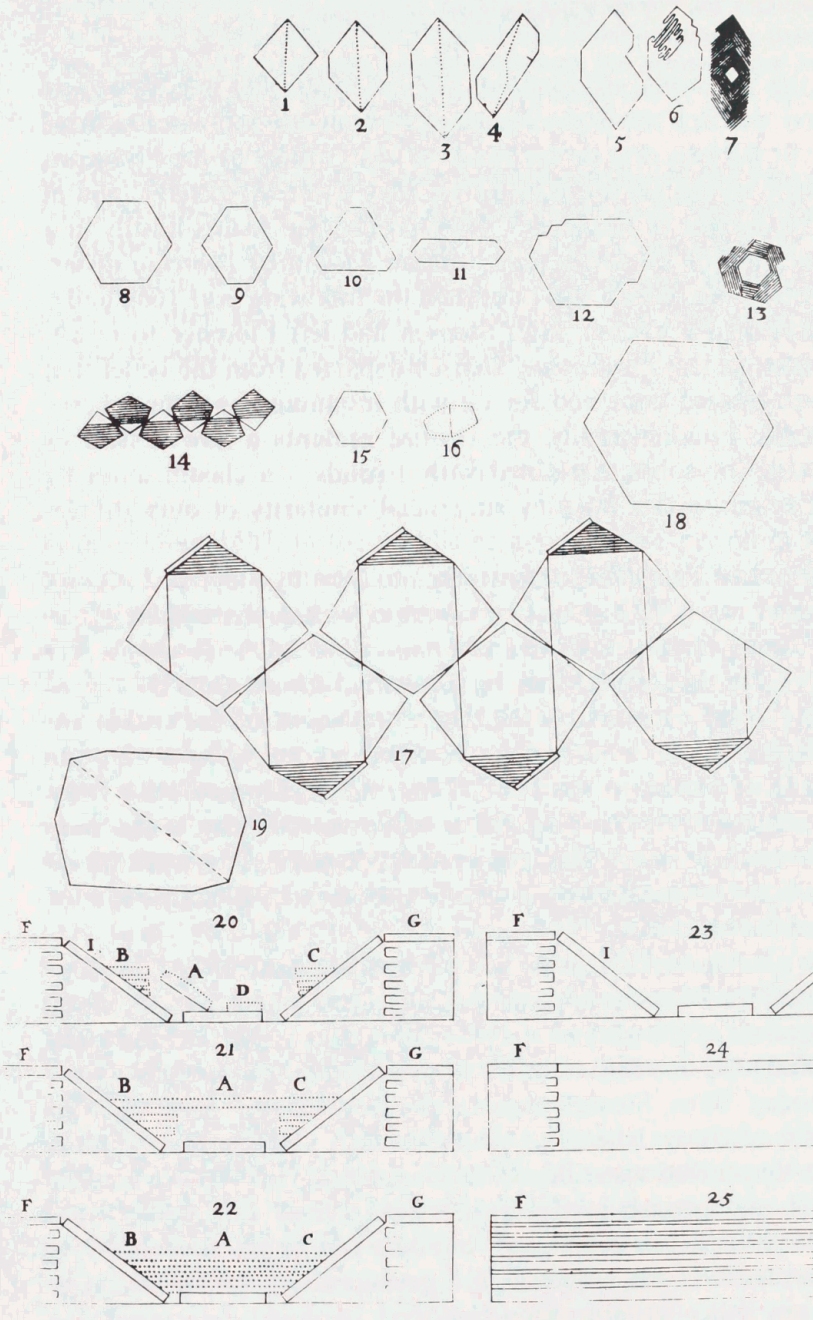

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
18
17
19
20
F
I
B
A
D
C
G
21
F
B
A
C
G
22
F
B
A
C
G
23
F
I
G
24
F
G
25
F
G

Fig. 8. Stratification of the earth's layers. *De solido intra solidum*, Florence 1669. Stensen's explication of the diagrams:

D25 shows a vertical section of Tuscany at the time when the rocky strata were still complete and parallel to the horizon. *D24* shows vast cavities eaten out either by the force of fires or waters, the upper strata being unbroken. *D23* shows mountains and valleys produced by the disruption of the upper strata. *D22* shows in the valleys new strata produced from the sea. *D21* shows part of the lower strata destroyed, the upper strata being unbroken. *D20* shows hills and valleys produced there by the disruption of the upper sandy strata.

In the words of Gould, Stensen "changed the world in the simplest and yet most profound way. He classified its objects differently."

By the example of the geology in Tuscany, Stensen aimed at making abundantly clear how the present state of anything discloses the past state of the same thing.[134] Thus he is, as concluded by Noe-Nygaard,[135] really the originator both of that part of geology which is based on fossils, paleontology, and of dynamic geology which seeks to unravel the processes in the earth's crust which have led to its present appearance. As noted by Rudwick[136] it is, however, at this point that "earlier commentators on the history of geology often felt constrained to turn regretfully from praising Steno as the forerunner of modern geology to apologising for his accomodation of Earth-history within the confines of a few thousand years". "Yet", Rudwick continues, "it is important to recognise that, in the context of his time, Steno's attempt to harmonise his observations with scriptural history was no insincere or forced reconciliation, but a natural synthesis of what he and his contemporaries regarded as two equally valid and complementary sources of evidence – the Book of God's Word and the Book of God's Works".

Other features of *De solido intra solidum* are the description of crystals and of Stensen's reflections on their growth by accretion without the presence, in nature, of a formative faculty. Crystals were also studied by Erasmus Bartholin, who published a work, *Experiments on Birefringent Icelandic Crystal*, at Copenhagen in the same year 1669. The works by Erasmus Bartholin and Niels Stensen, teacher and pupil, are considered basic to the science of crystallography.[137] Stensen's ideas were endorsed fully by Romé de l'Isle in the 1783 edition of his

134. *GP*, p 203.
135. P 181.
136. Rudwick, 1972, pp 68 ff. Note also that works on stratigraphy were still a century later dominated by the preception that most sediments were laid down during the great biblical flood.
137. Garboe, 1954.

Cristallographie.[138] Stensen's contributions to this discipline of science are centered around the particular problem of their growth,[139] showing that crystal faces grow parallel to themselves, keeping constant angles with one another – *non mutatis angulis* – meanwhile a sentence which appeared solely as "two throwaway lines in a figure caption":[140]

> Diagram 13 shows how sometimes the length and member of the sides in the plane of the base are changed in various ways as new crystalline material is added to the planes of the pyramids, without angles being changed.

Like Stensen's other main works, the English translation of *De solido intra solidum* was indeed well reviewed in the *Transactions of the Royal Society*, March 25, 1671, vol. 6, pp 2186-90:

> The Author of this Curious and Learned *Prodromus* apprehending, that he might be diverted for a great while from finishing his intended Dissertation touching the *Frame* and *Changes* of the *Earth*, and the *Manner* of the *Productions* made therein; thought fit to deliver in this Tract both a Scheme and a Breviate of the same; forasmuch as he doth not only delineate the Method, he hath therein observed, but also sums up the most considerable particulars of his whole Design.
>
> He saith then, that he hath divided that Dissertation of his into *Four* parts. The *First*, by way of Introduction, is to shew, that the Question about *Marine substances*, found at a great distance from the Sea, is ancient, pleasant and useful, and that, though the Solution thereof have been hitherto very uncertain, yet he hopeth he shall be able to bring it to a certainty. The *Second*, resolveth this General Problem (whence <p 2187> he conceiveth that the Explication of all the difficulties about this Subject depends,) *viz. A Natural Body of a certain Figure being given, to find arguments and marks in the Body it self, whereby to detect the Place and Manner of its Production*: Which Problem he affirms to have resolved, that no Sect of Philosophers shall find just cause to except against the Principles and Notions by him supposed for its Explication. The *Third* is design'd to examine the Particular *Solids* included in a *Solid*, according to the Laws discover'd in the Resolution of the General Problem. The *Fourth* is to represent, the different States of Constitutions of *Toscany* (for Instance) and propoundeth a way of Explicating the *Phænomena* of the *General Deluge*, not contradicting the Laws of Natural Motions.
>
> And so much for designed *Method*. As to the *Summ* of the most remarkable particulars of the whole work, it may be reduced to this.
>
> *First*, he comprehends, what he hath to offer about his above mentioned General Problem, in *three* Propositions; *One* is, that if a Solid Body be every way encompass'd with another Solid Body, *that* of the two was first hardned, which by the mutual contact expresseth on its surface the proprieties of the surface of the other. The *Second* is, that if a Solid Body be every way like another Solid Body, not only as to the condition of its surface, but also as to the inward frame and texture of its parts, it is

---

138. Burke, 1971, p 173.
139. Pedersen, *Steno and the origin of crystallography*, 1991, p 129.
140. *GP*, p 212. Stephen J. Gould hits an important point. Stensen did not formulate any "law" on the constancy of angles in crystals, but he respected this principle when drawing illustrations, and he made reference to it in the figure caption as indicated.

also like to it as to the Manner and Place of its production; excepting only those qualities of Place, which are often found in it, and are not any advantage or diasdvantage to the production of the Body there lodged. The *Third* is, that a Body produced according to the Laws of Nature, is produced out of a *Fluid*. Where yet he waveth the first Delineations in the production of Solid Bodys, but delivers several positions about their Increase.

Having thus generally consider'd a *Solid contain'd within a Solid*, he proceeds to a Particular examination of those various Solids, that are digg'd out of several parts of the Earth, as *Incrustations, Sediments* or Beds, *Angular Bodies, Shels* of Sea fishes, <p 2188> the shapes of *Cockles* and *Plants*, &c.

From the *Change* of the *Scite* of *Beds* he giveth an Account; 1. Of the Principal Origin of *Mountains, Hillocks* and *Valleys*, and their various Constitution, Matter, Shape, &c. 2. Of the Passages for *Springs* and *Winds* rushing out of Mountains, foetid Exhalations, hot Ebullitions; as also of the Changes of Hot Springs into Cold, and the Turning of the Course of Rivers another way; of Rivers, running in one place under ground, and rising again in another; of whole Countries being swallow'd up with their Houses and Trees; of great Lakes now appearing where Towns stood formerly, &c. 3. Of the many kinds of *variegated Stones*, as also of the Receptacles of *Minerals*; where do occur very good observations.

In his discourse about *Angular Bodies*, he delivers many considerable things about the Production of *Chrystals* in the Cavities of Stones, about their first Concretion between two Fluids, or between a Fluid and a Solid, or *in* a Fluid; as also about the *Motion* of the Chrystal in matter, whereby it is determin'd to the Planes of the all-ready form'd Chrystal: Concluding from his Observations, that extream Cold is not the efficient cause of Chrystals; nor that'tis the Ashes alone burnt by fire that turn into Glass; nor the force of the Fire alone that produceth Glass; and that'tis not beyond the power of Man, to discover a production of Glass without the violence of fire: Where, by the by, he intimates what it is, whence depends the main cause of the difference of Chrystal from Glass, both as to refraction and other Operations.

From Chrystals he passeth on to consider the Angular Bodies of *Iron* and *Copper*; and sheweth, how the production of them agreeth in some things with that of Chrystals, and how it differs from them.

Thence he goes on to *Diamonds*, and observeth, how they also are produced in a Fluid inclosed in the Cavities of Stones, together with the variety of their Figure. Next, he disourseth of *Marcasites*, and delivers also several Observations about the <p 2189> *Selenites*, and of *Talc*, and affirms in particular, that the Solid body of *Talc* may be dissolv'd into a Fluid, as being *coagulated* from a Fluid, though that dissolution cannot at all be perform'd by Fire, forasmuch as that part of it, which is able to dissolve it, flyes away by the torture of the Fire.

After this he proceeds to *Shells*, both taken out of the Sea, and found in Mountains; shewing, of what and how they are produced, and whence proceeds the variety of colours seen in them; and explaining particularly, how *Pearls* are produced, as well those, that being fastn'd to the Shels are not so very round, as those which by reason of the obstruction of the pores in the Animals surface acquire a round figure within the pores themselves: where occur many (in my opinion) very curious and uncommon Observations of the Coats of Pearls and the Shels of Pearl-bearing Fishes, and their difference; as also of the cause of the different Colours in Pearls; making it manifest, that though globuls made up of various coats may be contriv'd by Art, in imitation of Nature; yet to dispose their tunicles out of a series of threds by an apposition of one to another, whence depends the native splendor of Pearls, will be very hard to effect.

Next, he giveth an account of *Shels lying under-ground*, affirming, that they were

once the parts of Animals living in Water, and proving it by the sole inspection and consideration of those Shels themselves. Which done, he maketh out the particular *Phænomena* of divers of them found in *Toscany*. And what he hath said of Shels, he affirms also of other parts of Animals, and of the Animals themselves buryed in the Earth, such as are the Teeth of Sea dogs, the Back-bones of Fishes, various sorts of whole Fishes, Skuls, Horns, Teeth, Shanks and other Bones of Terrestrial Animals; where he informs us particularly, what to judge not only of the great number of Teeth brought away every year from *Maltha*; but also of the huge Thigh-bones, Skuls, Teeth, and other Bones digg'd out of the Earth.

<p 2190>

Which done, he labours to evince by a notable Instance, that the production of many Shels found in these times is to be referr'd to the times coincident with the General Deluge. And what he hath prov'd of Animals and their parts, he extends to *Vegetables* found under-ground; shewing withal, what may be conceived of the *Figures* of Plants appearing on Stones.

He concludeth this *Prodromus* with a remarkable Information, shewing, How we may from the present Face of the Earth, by an attentive view, discover the former state of it. Which he endeavours to make out by an Example taken from *Toscany*; in the present Face of which he conceiveth, that the obvious Inequalities proclaim to an heedful Observer manifest arguments and signs of Six different Changes happen'd therein; the face of it having been, by his Observations, twice fluid, twice plane and dry, and twice uneven; which as he attempts to demonstrate by an Induction of many places in *Toscany* view'd by himself, so he confirms it of the Whole Earth by the Descriptions of various parts of the World made by several Authors; obviating the chief difficulties, that may occur about each Face and particular Constitution of the Earth.

As early as in 1671, *De solido intra solidum* was translated into English. The interpreter, the secretary of the Royal Society of London, Henry Oldenburg, wrote in the preface:

It giveth very fair hopes, that by a due weighing of the particulars, therein laid down, the sagacious Inquirers into Nature may be much assisted to penetrate into the true knowledge of one of the *Great Masses* of the World, the EARTH, and therein to find not only the *Constitution* of the Whole, but also the several *Changes*, and the various *Productions* made in the Parts thereof; as the Excellent *Robert Boyle* hath of late Years, with great Acuteness as well as unwearied Industry, led us on a great way in the knowledge of another of the great Masses, the AIR; though the same also hath not been unmindful of considering this very subject, here treated of; forasmuch as He, before he would see or hear any thing of this *Prodromus*, did upon occasion candidly declare to the Author of this Version, (who *bona fide* here publickly attests it,)

First, that he doth, upon several inducements suppose, the generality of *Transparent* Gems or Precious Stones to have been once *Liquid* substances, and many of them, whilst they were either fluid, or at least soft, to have been imbraced with *Mineral Tinctures*, that con-coagulated with them; ...

Besides this, we cannot but take notice of what was intimated a good while ago in *Numb. 32.* of the *Phil. Transactions, p 628. viz.* that Mr *Robert Hook* had at that time ready some Discourses upon this very Argument, which, by reason of the many avocations he hath met with in the rebuilding of the City of *London*, and his attendance on the *R. Society*, he hath not yet been able quite to finish for the Press.

While its ideas are central to geology today, the role Stensen's work played in the early development of geology has been questioned.[141] The ideas were studied, but were not followed up by contemporary Danish scientists.[142] V. A. Eyles in 1958 discussed the possible mutual influence or even rivalry on priority with British scientists. The work was quoted by John Ray,[143] by John Woodward, and later by Leibniz[144] and von Humboldt.[145] In 1832 it was rediscovered by the French geologist, L. Elie de Beaumont.[146] Among the author's writings most attention is paid to this work in the *Encyclopedia Britanica*, and it is included among "One Hundred Books Famous in Science".[147]

1.10 Travels 1668-1670

In November 1668, Stensen set out on a journey through Italy, Austria, Hungary, Bohemia, Germany, the Netherlands, and then back to Florence. From the preface to *De solido intra solidum*, it appears that it had been the author's intention to return to Denmark; but he did not

---

141. Frängsmyr, 1971, p 204. Ellen Tan Drake attempts in her thesis to compare Stensen's and Hooke's contributions to the foundation of geology. Unfortunately this relevant task was based on less than available relevant material.
142. Garboe, 1958, p 117.
143. Wagner, 1986.
144. J. Woodwards, *Essay towards the National History of the Earth*, London 1695, and G. W. Leibniz, *Protogaea*, 1700. Cf. Hölder, pp 226 ff. *E*, I, p 66.
145. *Biography*, p 237.
146. L. Elie de Beaumont (1832): Fragmens géologique tirés de Stenon, ...

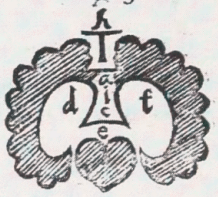
    Le nom de Stenon est classé depuis long-temps parmi ceux de ces auteurs ingénieux qui, devançant leur siècle, ont eu une sorte de pressentiment de découvertes qui ne devaient prendre rang parmi les vérités scientifiques que bien des années après leur mort. M. de Humboldt, dans son Essai géognostique sur le gisement des roches dans les deux hémispères, parle de lui dans les termes suivans: "Presque à la même époque (celle des travaux de Lister) Nicolas Stenon distingua le premier les roches (primitives) antérieures à l'existence des plantes et des animaux sur le globe, et ne renfermant, par conséquent, jamais des débris organiques, et les roches (secondaires) superposées aux premières et remplies de ces débris ..." (Humboldt, *Essai géognostique*, Paris 1823, p 38).

    J'ai pensé que, dans l'etat actuel des discussions relatives à la production des montagnes, il pourrait être intéressant pour quelques-uns des lecteurs des Annales d'avoir sous les yeux dans leur entier les idées géologiques de Stenon. Son ouvrages renferme aussi des aperçus fort justes, et très-remarquables pour l'époque, sur la structure et le mode d'accroissement des coquilles et sur la structure des cristaux de quartz et de fer oxidé et sulfuré. On pourrait certainement voir dans ces derniers un premier germe des découvertes de Haüy, ou au moins des recherches de Romé de l'Isle; mais j'ai craint, en les comprenant dans cet extrait, de lui donner une longueur hors de proportion avec le format des Annales.

    The introduction is followed by de Beaumont's extensively annotated French translation of excerpts from the *De solido intra solidum*. The identification of strata by fossils was independently developed by William Smith in 1815-20.
147. Horblit, 1964, no. 96.

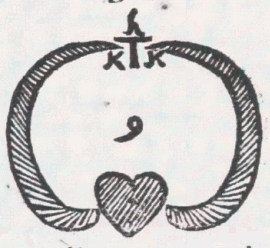
Cum in medio deberent uniri mediantibus partibus

fig. 3.



qvas (a) corpus calloſum, (i) ſeptum lucidum & (c) forniſcem appellant, prorſus erant ſeparatæ

fig. 4.



ita ut falx(h), qvæ naturaliter extra cavitatem ſita eſt, intra cavi-

Fig. 9. Sections of the brain in a normal and in a hydrocephalic calf, Innsbruck 1669. *Acta Med & Phil Hafn.* 1673 (printed 1675), vol. 2, pp 249-62.

do so. During the trip he visited various locations of special geological interest – where he found no contradicting evidence to his theories.[148]

During his travel, Stensen entertained various noble hosts by anatomical demonstrations. As a visitor to Archduchess Anna of Austria, the sister of the Tuscan Grand Duke, Ferdinando II, and Cardinal, Leopold, Stensen performed at Innsbruck, Tyrol, in June 1669 a dissection of a calf born with too much water in the head – hydrocephalus.[149] Largely ignored until recently the dissection is a fine piece of brain-pathology as well as of patho-physiology of hydrocephalus.[150] Stensen ascribed the malformation of the calf's head to a disorder in fetal life, namely a tumor (possibly a cranio-pharyngioma) that had obstructed the flow of cerebrospinal fluid outwards from the ventricles of the brain (Fig. 9). He did not deny, but used a *reductio ad absurdum*

148. See letter to Malpighi 27 October, 1669 (*E* 45), and Magalotti's letter to Oldenburg, Hall & Hall, 1965, vol. 4, p 347.
149. *OPH*, no. 28, English translation in "Steno on hydrocephalus". See also Hansen, 1992.
150. Gjerris & Snorrason, 1992, p 299.

to criticise a common point of view that maternal fantasies had caused the deformity. With ironic wit, he questioned that the mother of the deformed calf, a cow, had disturbing fantasies, a position easily maintained if the calf was not examined. In this case only autopsy made clear that a disease of the calf had caused the malformation. Centuries later the maternal mind's influence on fetal malformations was still under debate.[151] The study of congenital hydrocephalus, together with the earlier mentioned study of a child with heart malformations, qualify Stensen as a pioneer in teratological research. Both studies were published at Copenhagen by Thomas Bartholin in his *Acta medica & philosophica Hafniensia*.

During the journey Stensen met in Nuremberg in June 1669, Dr Johann Georg Volckamer (1616-1693), a later member of the German Leopoldina Academy, and made there an anatomical demonstration of the thoracic duct in a sheep.[152]

In the Netherlands, Stensen met friends from his earlier stay, and even his patron from Paris, Thévenot.[153] The plan for returning to Denmark was upset by news of the death of the Danish King in February 1670. Stensen's case probably would have had a very low priority during the first busy months of a new Danish administration, with a less than certain outcome. When he received the report of the fatal illness of the Grand Duke Ferdinand, Stensen returned to Florence.[154]

1.11 Back in Florence 1670-1672

The new Grand Duke, Cosimo III (1642-1723), received Stensen with open arms, granting him a pension as before and a well-equipped apartment in the Casino S. Marco. He became the geologist of the court, with such duties as the registration of the Grand Ducal collection of natural objects in Pisa.[155] He undertook at least one field-excursion outside Tuscany in the summer of 1671, which was described in two letters to the Grand Duke, published 100 years later.

The letters, *OPH* 29 and 30, describe two natural grottos in the Lower Alps, in the Trent region and in Lombardy. Both were known

151. Bang, 1801; Hammond, 1868; Ferreira, 1965.
152. Herrlinger, p 270. Harriet M. Hansen 1992.
153. *E* 51.
154. *E* 48.
155. *Indice di cose naturali*, with German translation, pp 141-229 in Scherz, *Vom Wege Niels Stensens*, 1956. English translation, pp 201-89 in Scherz, *Nicolaus Steno and his Indice*, 1958. The index exists in two versions, the original Pisan version is recorded by De Rosa, *Un inventario naturalistico inedito di Niccolò Stenone*, 1985.

for the phenomenon of the formation of ice within the grotto, particularly peculiar in the summer. Corra and Ferrari reevaluated Stensen's findings three hundred years later in 1971. On location, they were well able to appreciate Stensen's accurate findings and the striking reasons he adduced to refute the Aristotelian theory of antiperistasis, which he replaced by considerations relevant to what is now called subterranean meteorology. In this area of research, Corra and Ferrari refer to Stensen as being a precursor.

Stensen's aim had been to complete the treatise on solids. But he had developed new, all-consuming interests. In the Netherlands, he had engaged in religious controversies over his conversion. Back in Florence, he took up the debate. Among his opponents was a theologian of the German Reformed Church, Johannes Sylvius (d. 1690). Also the appearance of *Tractatus theologico-politicus* by Spinoza in early 1670 prompted Stensen to write a letter to his former friend in which he tried to turn him towards the consolation of the Roman Catholicism.[156] As epitomized by Kenneth D. Keele,[157] Stensen reproached Spinoza in the following way: "You do not think there exists any certainty but demonstrative certainty and are ignorant of faith." And he continues, "You cannot explain the sense of pleasure or pain apart from suppositions ... and likewise the whole philosophy of Descartes, however deliberately examined and reformed by you, cannot demonstratively explain to me this one phenomenon, namely how the impact of matter on matter is perceived by a soul that is united to matter." The latter remarks lead towards Stensen's unpublished essay on physiological psychology, see section 1.14.

Theological issues took up more and more time. Late in 1671 Stensen was permitted to devote all his time to religion for the next months. He had left Florence in 1668 as a natural scientist, but he had returned in 1670 as a theologian. He did not publish again on geology or on the muscle contraction. Also he never carried out plans to examine the water space in plants and animals.

The turn from science to faith was caused by an inner conviction, and found response at the Tuscan Court. Cosimo had been brought up with science, but lacked the engagement that had characterized both his father and uncle.[158] With interests running toward religion and morality, he was fully prepared to support the progress of Stensen.

---

156. *E* 63a=*E* 61.
157. Keele, 1968, p 231.
158. Yet a highly remarkable book dedication to Cosimo III is De Graaf, *De mulierum organis generatione*, Leiden 1672, probably a patronage mediated by Stensen.

A devastating matrimonial conflict and everlasting problems with the offspring are not reflected in their correspondence.

1.12 Anatomist to the Danish King 1672-1674

In response to a call from the new king of Denmark, Christian V (1646-1699), through the king's chancellor, Peder Griffenfelt, née Schumacher (1635-1699) (*E* 74), Stensen returned to Copenhagen on 13 July, 1672, after eight years abroad, to work as an anatomist. *Anatomus regius* or royal anatomist he was called this by Thomas Bartholin although no formal document exists to support this title.[159] Stensen stayed with his sister's family, and conducted anatomical investigations on many animal species, mostly for a circle of interested friends. Among these, Holger Jakobsen, Jacobæus (1650-1701), the younger brother of Matthias mentioned in chapter 1.5, was perhaps the only one who might properly be called his pupil.[160] Surrounded by active members of the early Copenhagen school of biology, Stensen's contributions are clearly the most important.[161]

On 29 January, 1673, Stensen gave a lecture, *OPH* 31, that marked

---

159. On Stensen's title and honorarium, see also Winslow's autobiography:

> M. Jacobæus qui m'affectionnoit très fort, m'encouragea très particulierement sur ma disposition et mon attachement pour l'anatomie et me fit esperer la charge d'anatomiste royal, qui avoit été établie en faveur de feu mon grand-oncle, le docteur Sténon, et vacante depuis son départ pour l'Italie, ajoutant même, qu'au lieu de son honoraire de quatre cens écus, j'en pourrois esperer l'augmentation de deux cens." Maar, 1912, pp 18-20.

160. See *OPH*, II: 26, pp 287-310. J. B. Winslow was a second generation pupil of Stensen, see previous note.

161. Cole, 1944, p 375:

> Steno, stimulated by his important researches on the female genital ducts and ova of the terrestrial vivipara, turned his attention to fishes, and the types selected were *Mustelus laevis, Acanthias vulgaris, Torpedo* and *Argentina sphyraena*. He gives an account in the shark *Mustelus* of a functional placenta which is connected with the gut of the foetus by a vitelline duct, as in the embryo of birds, forming by convergence a structure comparable with a cotelydon of the ruminant placenta. He gives us also, in *Mustelus* and *Acanthias*, one of the earliest descriptions and figures of the elasmobranch spiral intestine, which he names "intestinum cochleatum". He found the abdominal pores and discusses their function, and dissected out the auditory organ, noting that the semicircular canals were disposed in the three planes of space. He recognized that this structure was a sense organ consistent with the ear enclosed in spongy bone in birds, and in solid bone in man and quadrupeds. He discovered the sacculus, and correctly compared its soft white otolith with the stony otoliths of other fishes. He had already described in the selachian fishes the lateral line canals and the cartilaginous optic peduncle, and now informs us that the oviducts of *Acanthias* resembled those of the placental shark in that one of them contained a foetus, but that in this species and in the torpedo *there was no placenta*. In *Torpedo* he describes the electric organ, its characteristic vertical prismatic columns, and nerve supply. He does not, however, clearly associate the shock produced by the animal with the electric organ.

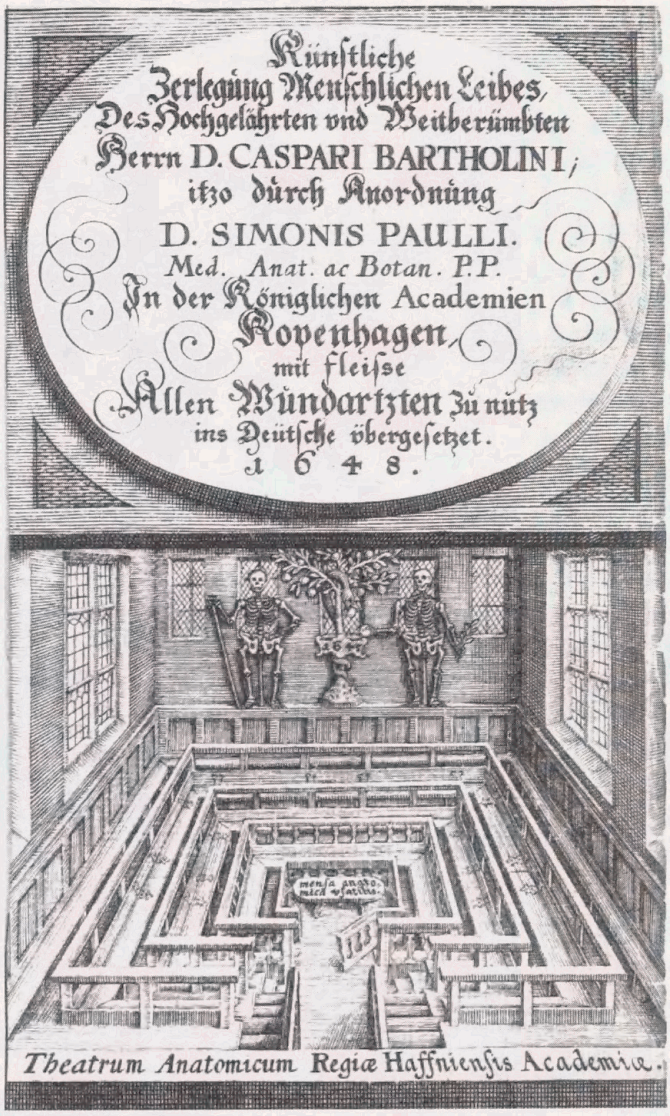


Fig. 10. The interior of the *Copenhagen Theatrum Anatomicum*. From Simon Paulli's German translation, 1648, of Caspar Bartholin's *Anatomy*.

the re-opening of the anatomical theatre (Fig. 10), which had lain idle for years. It marked the beginning of an anatomical demonstration lasting ten days. The lecture, published in Thomas Bartholin's *Acta medica & philosophica Hafniensia*, is an essay dedicated to philosophy of science, in which Stensen expressed his faith in teaching based on observation and critical reflection. Stensen's subsequent public dissection of a female body delivered by the hang-man, took place on 30, 31 January, 1, 3, 4, 5, 6, 7, and 8 February. The dissection was witnessed by Holger Jacobæus, who wrote down an account, in fact a small

hand-book of human and comparative biology, which was however never published but is presented here in translation for the first time. During preparation for this edition I noticed a written report on Stensen's *Prooemium* on 29 January, not edited by Maar in *OPH* 36. August Ziggelaar kindly translated and commented this text, which may be considered a learned listener's excerpt, or perhaps the speaker's own synopsis of the lecture. I shall further comment the lecture in chapter 3.

Another dissection from the Copenhagen period is that of an eagle – in academic circles the symbol of the soul of Plato – performed in the house of Ole Borch on 4 April 1673 (Fig. 11). The account became Stensen's last published work in science. According to Cole:[162]

> Steno's dissections of the muscles of *Aquila* ... is one of the most remarkable essays in zootomy published up to his time, and it is perhaps more detailed and reliable than almost any other, but the unfortunate absence of illustrations handicaps the labours of his interpreters.

An otherwise detailed description of the muscles of the eagle is remarkable for the absence of any mention of Stensen's geometrical theory of muscle contraction.

The Copenhagen lecture and various anatomical demonstrations concluded Stensen's work as a scientist. From now on, he devoted all energy and talents to God and the Church, but he never condemned his former life, nor science as such. In 1674 he wrote in a letter:[163] "God's presence speaks to us so openly in the ingenuity of nature and in the gifts He has bestowed upon us to research ... Sometimes I wonder if I promote the study of curiosities or not, when unconsciously I regard so many circumstances which might be referred to the real eternity, used for the illusory eternity of the ink."

As a Catholic he was excluded from any formal affiliation with the university, which was a Lutheran institution. When he became involved in a religious dispute (*E* 91) he asked the King's chancellor for permission to leave to become a teacher to the Tuscan crown prince (*E* 95), a permission that was granted by the King on 14 July 1674 (*E* 96). Letters from Copenhagen, *E* 85 and 86, reveal Stensen's burning interest in missionary work for the Catholic church, however for the moment impossible to realise, which seems to have been another reason for his departure.

Stensen left without expressing any bitterness, unlike Denmark's first great scientist, the astronomer and nobleman Tycho Brahe (1546-

---

162. *Ibid.* p 383.
163. *Positio*, p 215.

Fig. 11. Holger Jacobæus's drawing of the first eagle dissected by Niels Stensen in Copenhagen on 7 January 1673. From *Exercitia academica*. Royal Library, Copenhagen.

1601), who on being expelled by King Christian IV in 1597, at Altona near Hamburg shed angry tears in an elegy entitled "Denmark, What is My Offence?" By contrast, Stensen's words, *E* 108, probably written from Florence in 1675 to Ole Borch, were: "Homeland, I have sinned!". The sin to which he referred was having waited so long before converting to Catholicism. Nevertheless, for a few years to come, Stensen was still highly respected in Denmark for his science, as evidenced by the fact that prominent young Danish scientists like Holger

Jacobæus and Thomas Bartholin's two sons, came to visit him in Italy,[164] and by the publication of several articles, including the *Prooemium* lecture, by Thomas Bartholin.

On the way back to Florence, Stensen visited the Netherlands for the third time, in a fruitless effort to persuade Jan Swammerdam, who was in the midst of a religious crisis, to go to Italy to become a scientist at the court of the Grand Duke, and to convert to Catholicism (*E* 99).

1.13 Preparation 1675-1677

After returning to Florence around New Year's Day, 1675, Stensen prepared himself to become a priest and was ordained in the middle of April 1675. For two years he worked as tutor and moral preceptor to the Crown Prince.[165] From that period is preserved the manuscript of a sermon, *Ornaments: Monuments, Signs, Arguments*, in which Stensen made use of precious stones and their origin in nature to depict redundancy and the inexhausible store of knowledge in Nature:[166]

> How much wood in forests, or fruit from trees goes rotten without ever serving man or beast? How many millions of pearl-bearing mussels remain buried with their pearls in the sediment of the sea? Whoever considers the problem seriously, must admit that the greatest part of earthly things are, to our knowledge superfluous. However no one can say whether they are really superfluous or useless because of this. It is one thing to consider such things within the bounds of our own intelligence, and another thing to examine them in relation to the total sequence of created things. It would be equally stupid to call useless something whose purpose we are ignorant of, and to deny the existence of things we have not seen.

The great number and variety of objects in the universe, grains of the sand, stars in the sky, led Stensen to express that God is all things existing.[167] Later in the sermon is found a remarkable note on linguistics: "we can think of the example of the letters of the alphabet which the scholar and linguist scarcely looks at because he is concentrating on the sense of the whole word. On the other hand, the man who understands neither the language nor the writing, gazes at the letters in admiration especially if they are artistically drawn."

---

164. Holger Jacobæus, *Rejsebog 1671-1692*, pp 106 and 137.
165. Ferdinandino (1663-1713) never ascended as he died before his father, Cosimo III. Cf. Hibbert, *Cosimo III and the Grand Prince Ferdinandino*, 1980, pp 292 ff.
166. *GP*, pp 249-67. English translation by Mrs M.Rohde. Maar has used the *Ornaments* as an example of how Stensen retrograded in his development after taking Holy Orders. See note 172.
167. *sed qvod "omnia in omnibus" existens uno qvasi intuitu omnium numeram videat. GP*, p 259.

Upon an invitation from Hanover by the Catholic convert, Duke Johann Friedrich of Brunswick-Lüneburg, the brother of Denmark's dowager Queen, Sophie Amalie, Stensen went to Rome, where on 21 August, 1677 he was appointed by Innocent IX as apostolic vicar of the northern missions. On 19 September, he was consecrated a bishop with the titular diocese of Titiopolis, an ancient see in Anatolia, which had been in Islamic hands for many years (*E* 136).

1.14 Bishop in Germany 1677-1686

Until the end of June 1680 Stensen ministered from Hanover to the scattered remnants of Catholicism in northern Germany and Denmark.[168] As Bishop, Stensen was responsible for a large area: Brunswick, Mecklenburg, Hamburg, Altona, Schleswig, and Holstein, and, from 1678, also Denmark and Norway.

Niels Stensen, the bishop, was often involved in confessional discussions. The Duke and his wife were Catholic converts, but the younger brother, Ernst August, and his wife, Sophia, remained Protestants. Although they delighted in animated discussions, they refused to take a serious view of the matter. A more worthy antagonist was the Duke's councillor and librarian, the philosopher and mathematician, Gottfried Wilhelm Leibniz (1646-1716). Leibniz admired Stensen as scientist and made use of the *Prodromus* while preparing his *Protogaea*. But Leibniz deplored the fact that Stensen had given up revealing the greatness of the Creator in creation, and he was unable to understand Stensen's reasons. Provoked by a question by Leibniz, Stensen described how the study of anatomy had undermined his confidence in the system of Descartes. How could a system with errors detectable by a 10-year old boy in one glance give him any assurance when dealing with questions on God and the soul? Several theological works and forty-five sermons are preserved from that period.[169] A written notice, OTH I: 450, reveals that Stensen performed an anatomical demonstration on the heart and brain at a colloquium of theologians in the city of Celle in 1680.

After the death of the Duke Johann Friedrich, his Lutheran brother

---

168. The sources from Stensen's period as a bishop vastly exceed my capacity for processing. Brief accounts in English are given by Pålsson, 1988, and by Scherz and Beck, 1988. Sr. Miriam Mortensen, O.S.B., has presented a very readable and detailed account in *Skønnest af alt*, 1993. Olden-Jørgensen, 1992, has collected essential quotations in *Niels Steensens sentenser og spiritualitet*. For more extensive information and sources, the reader should consult Scherz's biography in German.

169. *OTH*, II, pp 151-375. See also *E* I, pp 65-69.

took office, and Stensen had to leave Hanover. He was then appointed an Auxiliary Bishop to the Prince Bishop, Ferdinand von Fürstenberg, of Paderborn and Münster in Westphalia. Here, he found himself in a Catholic homeland with a long ecclesiastical tradition. The easy-going ways of the clergy, however, did not fit with the demands of the ascetic in Stensen. For three years he worked hard and against strong opposition for pastoral reform in the area. Then, by the simoniac election of the successor of the Prince Bishop, he left Münster in protest on 1 September, 1683, to live as a missionary in his vicariate. As priest and bishop, Stensen advocated a life permeated with God. Every minute of the day was to be be spent in doing the will of God and in the observance of poverty, modesty, and faithfulness to prayer. Stensen lived as he preached, and although he received considerable amounts of money from salaries and from the Grand Duke of Tuscany, he lived as frugally as possible, spending all he had on deserving converts.

During the last period of life, Stensen lived in self-inflicted poverty and renunciation at Hamburg.[170] An indication of an unimpaired intellect is preserved in a manuscript, ending on a letter-envelop, reviewing confirmed knowledge of brain and nerve function. This uncompleted essay on physiological psychology is presumed to be from the Hamburg period because an address of Stensen, the apostolic vicar at Hamburg, is found on the reverse of the final page in which one of the scientific sketches are drawn.[171] Despite being incomplete and at places illegible, the majority of the text is of self-explanatory clarity. This essay (see *Addendum*, p 147) indicates a clear scientifically evaluating mind and calls into question Wilhelm Maar's position on Stensen's later development.[172]

After two years of apostolic activity in Hamburg and a short, private visit to Copenhagen, Stensen wrote to ask the Pope for permission

---

170. From the description by Johann von Rosen (?-1699), a Catholic convert and Lithuanian nobleman. The following is an excerpt (Larsen, 1933):

> Je le trovay sans maison, sans valet, depourveu de toutes les commoditez de la vie, maigre, pasle, decharné, mais avec cela si gay, que son visage seul inspiroit la devotion; il étoit habillé comme un pauvre, couvert d'un vieux manteau, qui lui servoit pour l'hyver et pour l'été, vivoit en veritable pauvre, dans un abandon parfait à la providence de Dieu, de qui il attendoit sa vie et sa subsistence du jour a la journée, ayant tousjours ces paroles de Tertulien dans la bouche: *Christiano non est crastinum*."

171. The manuscript is in the same volume in the Biblioteca Nazionale Centrale of Florence as the *Chaos*-manuscript, see Fig. 1, and the printer's manuscript to *De solido intra solidum*.

172. Maar, 1910, *Life and works of Nicolaus Steno*: "From about the time when *Steno* took Holy Orders his development retrograded, even as far as his way of looking at nature was concerned", (*OPH* p XII). Maar did not know the existence of this text recovered in 1946 by Scherz.

to retire to Leghorn in Italy for study and meditation (*E* 409) a permission that was granted on 16 July 1685 (*E* 414). Nevertheless, he was detained by conditions in Hamburg. In December he had to go to Schwerin, a small Catholic outpost of Mecklenburg, to serve the congregation.

The visit, intended to be short, had lasted for almost a year when the local priest, Father Steffani, fell ill and died (*E* 476). Shortly after Stensen himself fell acutely ill. He described the symptoms in two letters, one to his benefactor, Cosimo III, and the second to his friend from the student days at Leiden, the Tuscan ambassador at Hamburg, Theodor Kerckring, giving the latter instructions about arrangements after his death (*E* 477 and 478). The letters are written with a clear mind on the day before he died. Stensen's own diagnosis was that a stone had formed in a fold of the bladder causing an inflammation. He then remarked, "for all things be the divine goodness thanked and praised!" After four days of severely painful colic with swelling of the abdomen and the passing of bloody urine in small amounts, Niels Stensen died on 5 December 1686 (or 25 November in the old calendar).[173] His last recorded words were *Jesus sis mihi Jesus et miseriordiam tuam, Domine, in æternum cantabo.*[174]

---

173. Johann von Rosen, *La vie de Nicolas Stenon*:

> et lors qu'il sentit approcher la mort, il nous dit: "Allez, mes enfants, c'est assés. dites a present les prieres pour un mourant"; pendant les quelles il expira, en prononçant le nom de Jesus, le 25. de Novembre, le matin, un peu avant 7 heure, à l'age de 48. ans.

Larsen, 1933, pp 152-53.

174. ibid., p 152. *Positio*, p XC.

2. Reputation

A letter to Cosimo III written by a friend of Stensen from the student years at Leiden, Theodor Kerckring, the physician and, on Stensen's recommendation, the representative of Tuscany at Hamburg, describes Niels Stensen's last days and death (Fig. 12):

1686, 11 December, Hamburg

Most Serene Prince, most kind Lord.

Two days ago i learned unexpectedly and not without great sorrow of soul of the death of the most reverend bishop of Titiopolis, of whose illness and death I heard of almost at the same time. For he had been ill four days, and nephritic and colic suffering were the cause of his sudden death. On the 25th day of the month, in the old style, in the seventh hour of the morning he departed this life. This fact I have decided to make known to your Serenity. I have been informed that the blessed prelate, as we now hope him to be, had written a few hours before his death to your Serenity from Schwerin, but had not yet sent it. I wish to make known to your Serenity alone the fact that the blessed prelate at the onset of this illness asked that a priest from Lübeck, of the Society of Jesus, come to administer the sacraments to him, but that the Father excused himself from coming, so that, lacking a priest, he died without the sacraments. I have sent my secretary to Schwerin and one 70 imperiales that the body of the deceased be buried somewhere in the church without any ceremony and pomp until I am made more certain by your Serenity whether you would prefer that, in honor to the body of the deceased, it be buried according to his episcopal dignity. I therefore await from your Serenity what you wish me to do in this matter. This bishop died with a great reputation for sanctity, not only among Catholics, but even among Lutherans who unanimously made the pronouncement about him "that he led a most holy life".[175]

At the expense of Cosimo III, the body was brought from Hamburg by ship to Leghorn to be laid to rest in the crypt underneath the Church of San Lorenzo in Florence, the burial church of the Medici Grand Dukes. The coffin was opened in 1953 because of the emerging canonization process.[176] After a solemn procession through the city, the remains were transferred to a chapel in the right transept facing the high altar of San Lorenzo, where it is placed in an ancient Christian sarcophagus.

In 1974 the Vatican published a voluminous report mostly in Italian, the *Positio*,[177] as the grounds for Stensen's beatification, which was finally celebrated on 23 October, 1988 at St. Peter's Basilica in Rome by the Pope, John Paul II, with about twenty-thousand worshippers,

175. Additamentum 25 in Epistolæ, vol. 2. Translated by Sister M. Emmanuel Collins.
176. Scherz, *Im Rufe der Heiligkeit*. Gotfredsen, 1954.
177. Veraja, 1974. See also Pålsson, 1988, pp 69-75.

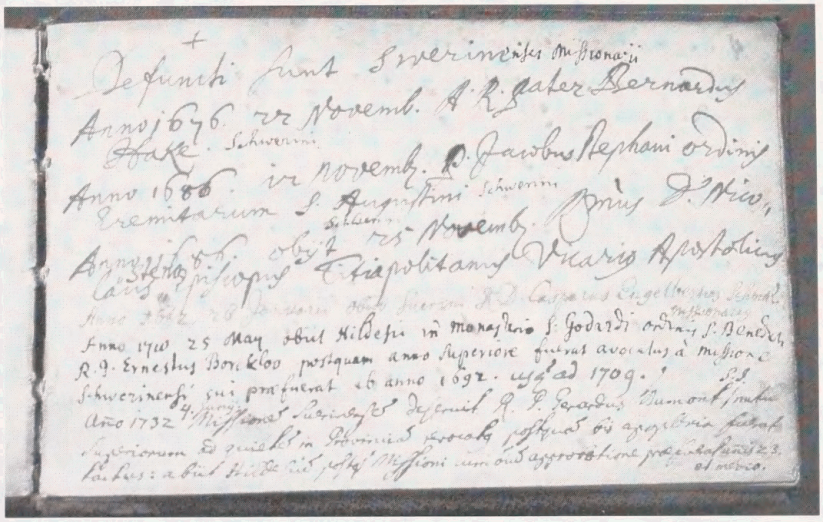


Fig. 12. The inscription of the demise of Father Steffani and the Bishop Steno, 1686, in the church book of Schwerin in Mecklenburg.

many of whom were from Denmark and Germany, as well as from Tuscany.[178]

Stensen's writings can be studied in their original language in three monumental, two-volume works: the *Opera philosophica*, edited by Vilhelm Maar in 1910; the *Opera theologica*, edited by Knud Larsen and Gustav Scherz in 1944; and the *Epistolae*, edited by Gustav Scherz assisted by Hans Ræder in 1952. Selected works have been translated in several languages.

---

178. The rite of beatification consisted of a formal request to Pope John Paul II read during the first part of the celebration of the Eucharist by Monsignor Ludwig Averkamp, Bishop of Osnabrück, assisted by Monsignor Hans Ludvig Martensen, Bishop of Copenhagen, petitioning him to ascribe Niels Stensen, the venerable servant of God, among the number of the beatified: *Beatissime Pater, Ordinarius Osnabrügensis humillime a Sanctitate tua petit ut Venerabilem Servum Dei Nicolaum Stensen, numero adscribere benignissime digneris.*

The Pope, then solemnly proclaimed the beatification of Niels Stensen and authorized the celebration of his feast on his birthday [sic!], December 5, in certain areas: *Nos, vota fratris nostri Ludovici Averkamp, Episcopi Osnabrügensis, necnon plurimorum aliorum Fratrum in Episcopatu, multorumque christifidelium explentes, de Congregationis pro Causis Sanctorum consulto, Auctoritate Nostra Apostolica facultatem facimus, ut Venerabilis Servus Dei Nicolaus Stensen, Beati nomine in posterum appeletur, eiusque festum die ipsius natali, idest quinta decembris, in locis et modis iure statutis, quotannis celebrari possit. In nomine Patris et Filii et Spiritus Sancti.*

From *Beatificazione del Servo di Dio Niels Stensen*. Basilica Vaticana 23 ottobre 1988, Rome, pp 29-30.

Stensen's fame is made evident by the steady increase in the number of publications as well as by paintings, musical compositions, and monuments at public places and teaching institutions in Denmark, Germany, Austria, Switzerland and Italy.[179] Seven academic dissertations treat Stensen's work to which may be added the "Abschiedsvorlesung" in 1978 by the late Professor Adolf Faller.

Academic Dissertations on Niels Stensen

1956 G. Scherz: *Vom Wege Niels Stensens.* Copenhagen, Denmark.

1968 J. G. Vugs: *Leven en Werk van Niels Stensen.* Leiden, Holland.

1969 M. Marzollo: *Anatomia e fisiologia del musculo nell'opera di Nicolò Stenone.* Brescia, Italy.

1981 E. T. Drake: *Robert Hooke and the foundation of geology: a comparison of Steno and Hooke ...* Oregon, U.S.A.

1986 U. Heida: *Niels Stensen und seine Fachkollegen.* Hamburg, Germany.

1992 K.-T. Hsu: *Nicolaus Steno and his sources.* Oklahoma, U.S.A.

1995 J. Heng: *Niels Stensen on anatomy: Method and context.* Toronto, Canada, in press.

Stensen's second homeland, Tuscany, marked the tercentenary of his death by two separate exhibitions of works and letters at the Biblioteca Laurentiana and in the Sala Donatello at Florence.[180] Florence also arranged a conference on Stensen's life and work.[181] In 1989 a memorial plaque donated from Denmark was placed at the Pontifical Academy of Sciences in Rome.[182] In 1994 Denmark's Museum for the History of Sciences, called the Steno-Museum, was inaugurated in Århus at the campus of the university.

There is almost an exponential growth in the number of publications recorded by Michael Jensen in his Stensen-bibliography of 2600 entries. Up to 1870 there was on the average less than one publication per year, followed by one to two publications per year up to 1930.

---

179. Anne-Liese Thomasen, *Der Wandel des Stensenbildes*, pp 152-66 in Bierbaum and Faller, 1979.
180. Negri, Morello, Galluzzi and Bussi, 1986. De Rosa 1986.
181. *Il futuro dell'uomo*, 1987.
182. *Pontifica Academia Scientiarum*, 1989.

Subsequently there has been an average of fourteen publications per year up to 1980.

The celebration of the 350th anniversary of Niels Stensen's birth in 1986, the 300th year of his death and the beatification in 1988, have stimulated a great number of publications and reprints of Stensen's works. The first translation of Stensen's collected scientific work into a modern language is the Italian edition of 1986 by Luciano Casella and Enrico Coturri with several translators. The geological works were published in English translation in 1969 by Gustav Scherz, and Stensen's correspondence, almost 500 letters, were edited in Danish translation in 1987 by Harriet M. Hansen with several translators from the papers left by Gustav Scherz and Karen Plovgaard. Gustav Scherz's biography in German was published posthumously in two volumes in 1987-88 by Harriet M. Hansen.[183] Illustrated biographies were written in German by Hermann Wieh and in Danish and English by Harald Moe. A short biography by Scherz & Beck was published in five languages. Recently Sr Miriam Mortensen wrote a new biography in Danish. Except on geological issues, remarkably few publications on Stensen are by English-speaking writers. A critical analysis of Stensen's extensive theological writings, more voluminous than those in science, awaits a scholar to resume the work initiated by Knud Larsen and Gustav Scherz.

183. The scholarly biography by Gustav Scherz was published in the former German Democratic Republic. The number of copies authorized for circulation soon proved far less than the demand. This work highly deserves to be reissued and translated.

3. Reflections on Niels Stensen's Scientific Method

The title under which Niels Stensen's collected scientific works was published in 1910 by Vilhelm Maar is the *Opera philosophica*. Recently the purpose of this title was questioned.[184] An answer does require the review of its contents. Earlier studies are:

C.C.A. Gosch (1832-1913),[185] the Danish zoologist and diplomat, in a fundamental study in 1873 stressed that Stensen's main object in research was to obtain knowledge of animals and nature. He pursued these objects in a proper manner, although less obedient to Baconian imperatives than desirable. He almost never repeated what others had said or found. Quite surprising and untenable after the detection of Stensen's *Chaos*-manuscript in 1946, is Gosch's remark that Stensen was not well-read, a point of view already expressed by the French encyclopedist of medicine, Portal.[186] Gosch found, nevertheless, that Stensen's communications were carefully worked out, so carefully that little was to be added by posterity, except as a result of new investigative methods. A noteworthy point in zoological and geological science was Stensen's attempt to reduce his views to the simplest possible mechanical and chemical processes.[187] Gosch adds that, without creating his own school, Stensen has become the great inspiration, a voice speaking unimpaired by time through the writings. Unconvinced by solutions to existential questions based on Descartes's method, Stensen became a sceptic and thereby was forced into the opposite extreme, that of "ultramontanism".

Through scholarly editions Maar and Scherz are the great compilers

---

184. The question was raised by H.-J. Schmalor, 1987, in reviewing Michael Jensen's *Bibliographia Nicolai Stenonis*: "Die erste Gruppe bringt 36 "Opera philosophica" – woher diese Bezeichnung kommt, bleibt unklar."
185. Gosch 1873, p 244 ff.
186. Portal 1770, III: 183.
187. This is a frequently expressed view on Stensen, which I do not share. The commentator ascribes to Stensen a subjectivity which he avoided, see e.g. *OPH* II: 22, p 70, where he says that he did not like to explain problems in complex and extraordinary things by means of simple examples. As far as I can see, Stensen described processes as they were, sometimes simple, like those on the production of tears, ear wax and saliva from glands, and other times complicated, like in myology which took science more than 300 years fully to appreciate.

of Stensen's writings, equally dedicated in spite of highly divergent points of departure.

VILHELM MAAR (1871-1940), the Danish physiologist and medical historian, concluded that Stensen distinguished himself perhaps above all through his scientific method. "He asked his questions and gave his answers as a scientist of the twentieth century; and deeply religious though he was, he never for a moment introduced any supernatural element in his solutions of problems of natural science ... His genius reveals itself in the conclusions, which he draws from his discoveries, and in the generalizations which he makes. His conclusions are not only astonishing by their number, but still more by their soundness and clearness, and yet perhaps most of all admirable by their correctness and their scope, being such that in some cases they have not been fully appreciated until now, some two hundred and fifty years after their first appearance."[188]

GUSTAV SCHERZ (1895-1971),[189] the Austrian-born Danish Redemptorist, in a scholarly manner and in great detail described the life of Stensen and his relation to contemporary scientists and philosophers, and also his resolve never to yield to unjustified authority. Scherz noted Stensen's increasingly critical attitude toward the teaching of Descartes and his followers, his initial attraction to and later disappointment with Spinoza's system. Scherz observed that "Stensen felt himself much closer to Galileo".[190]

MARTIN J. S. RUDWICK (1932–) found similar features which reflect the Galilean tradition in which Stensen was working. Focusing on paleontology, Rudwick described Stensen's methods in science:

> (1) The problem was considered solely as one of efficient causation: the purposes of tongue-stones, and specifically their medical or natural-magical 'virtues', were not mentioned even to be refuted.
> (2) Steno abandoned the earlier encyclopedic tradition of compiling all previous opinions on the subject, and scarcely mentioned any but his own contemporaries.
> (3) He made a sharp distinction between his observed facts about tongue-stones and his "conjectures" from these facts, listing the observations first, and then citing them at appropriate points in his arguments, almost in the manner of a mathematical theorem. Although this mathematical form was more apparent than real, he was certainly trying to construct a connected, persuasive argument leading step by step from observation through inference to conclusion. This reflects an awareness of the problems of method in science, and of the need to conduct scientific discussion within a community committed to rational argument on the basis of empirical observation. Thus, although Steno was probably convinced in his own

188. Maar in "Life and works of Nicolaus Steno", the preface to "Nicolai Stenonis Opera Philosophica", vol. 1, p XII.
189. Scherz's Biography: Klar, 1972.
190. Scherz 1968, "Nicolaus Steno the humanist", p 297.

> mind that tongue-stones were the true teeth of fossil sharks, he disowned any claim to certainty in the matter: he said that his essay would merely present the case for their organic origin, which could then be countered, as in a law-suit, by the opposite case for their origin *in situ* within the rocks.[191]

I agree with Rudwick's first two points, and also with his third point about Stensen's clear order of arguments: in the *Canis carchariae* eleven observations, *historiae*, on qualities of clay and rocks and such bodies as the tongue-stones found within them, are followed by six conjectures, *conjecturae*, on how these bodies might have come there. But I see no persuasive connecting argument leading from observation to conclusion in this treatise. By designating some claims as conjectures, Stensen seems to me to signal that he was dealing with questions that were out of reach of direct observation. In the first English edition of the *Canis carchariae*, Garboe refrained from any such interpretation: "It is very fascinating to follow his thoughts. But so concentrated is the literary form he uses that the best one can do is to let the small, but fundamental, treatise speak in its own fresh language".[192]

Hsu, elaborating in a recent dissertation on the remark about the resemblance of the form used for writing the *Canis carchariae* to that of a law-suit, on the contrary, has interpreted the timidity of Stensen's conjectures as a matter of style and presentation. Hsu proposes that Stensen adopted his written style in order not to antagonise powerful figures who held opposing views on the origin of *glossopetrae*.[193] I doubt the validity of Hsu's position, firstly because I find the conjectures to have a methodological function, and I find my position confirmed in the following sentence from *Prooemium*: [on the intricate structures of muscle, tendon, and skin] "of which we grasp very little and this only by conjecture since they escape every sense";[194] secondly because I do not find trace of such timidity, as hinted at by Hsu, in Stensen's other writings: at Amsterdam and Copenhagen he argued openly against his professors, in Paris against Descartes's followers, and at Florence fiercely against Borelli.

Another original contribution in Stensen's writings was the persistent effort of the author to collect arguments against his own propositions. This effort is overt already in the theses on glands, muscle, heart, and brain, becoming an integral part of the argumentation in the *Canis carchariae*. When eventually failing to find contradicting evidence, Stensen made known his conclusion. Based on previous conjec-

---

191. Rudwick 1972, p 51.
192. Steno, (ed. by Garboe), 1958, p 5.
193. Hsu, *Nicolaus Steno and his sources*, p 230.
194. *nec fere nisi per conjecturam asseqvimur, OPH* II: 31, p 253.

tures he proceeded to the main point, conjecture no. 6, "there seems to be no objection to the opinion that bodies dug from the ground which resemble parts of animals should be considered to have been parts of animals". He finally repeated this in specific terms: "it seems to me that those who assert that large tongue-stones are the teeth of a shark are not far from the truth" – *a vero non multum recedere.*

To sum up: plain observations prompted bold conjectures which the author himself attempted, and invited his reader to refute, and not to confirm! Although based on conjectures, Stensen concluded that those people who express the final conjecture are not far from the truth – the Popperian word *verisimilitude* lies almost on the tip of the pen.[195] By applying bold conjectures and attempted falsification, Stensen is close to the method of science discussed by Karl R. Popper (1902-1994), and somewhat falling out with trends in the scientific method of his own period.

Having examined many passages in Stensen's work the late Swiss anatomist and Stensen-biographer, ADOLF FALLER,[196] listed the important aspects of Stensen's criticism of scientific methodology:

the uncertainty of sense knowledge;
the limits of methodology;
the narrowness of enquiry;
the influence of human affect;
the dangers of analogy and speculation; and
the weakness of human understanding.

The main epistemologic elements of Stensen's opinions and utterances, according to Faller, are:

the problem of certainty in scientific knowledge;
the methodological doubt;
the part played by sense knowledge and by inductive and deductive procedures;
the ordering and gathering of facts;
scientific nomenclature;
the logical connection of facts;
hypothesis and theory;
verification by repeated experiment; and
quantitative-mathematical aspects.

---

195. I was at first hand inclined to believe that the Popperian word *verisimilitude* was not to be found in Stensen. I am grateful to August Ziggelaar, S.J., Ph.D., for indicating the following sentence from *Canis Carchariae*, in the conjecture I (*GP*, p 98): *cum terra mollior eadem corpora multis in locis verosimiliter*. In this sentence Stensen has replaced the word *evidenter* by *verosimiliter* in the printing manuscript, thus indicating a distinction. 'Probably' in Pollock's translation makes less sense to me than Ziggelaar's suggestion 'likely'.

196. Faller 1980, "Elemente einer Wissenschaftslehre und einer Wissenschaftskritik in den Schriften von Niels Stensen".

Faller stressed the influence of Galileo upon the whole of the seventeenth century which caused scientists independently to come to similar attitudes and opinions. Faller listed as the most important sources on science methodology, Stensen's *De musculis, Discours, De solido intra solidum,* and *Prooemium.* However, I would add the preface of the *Elementorum myologiæ specimen* with the attached letter to Thévenot. Moreover, I do not agree with Faller that Stensen's early scientific works included only few remarks on methodology. Stensen's first scientific work,[197] the *De glandulis oris*, contained such remarks in its preface (see below), and in §§4 and 5 of this work, Stensen discussed the veil of similarity, *illud similitudinis velum*, hiding the proper cognition of glands. Another example is §32 in which Stensen reflected on the problem of induction: "for it does not hold that since neither I nor anyone has yet seen it, therefore it does not exist".[198] Without adding "positive" information, two polemic papers also from the Leiden period, *OPH* 4 and 13, exemplify how Stensen evaluated one theory against another. Thus, in my judgement, Niels Stensen added comments on scientific method *throughout* his scientific writings. He thereby revealed the method he himself used, and those he avoided.

Rothschuh in 1968 and Heida in 1986 both describe Stensen as the methodical man who step by step analyzed every new finding before evaluating it in full context, in contrast to the systematical man, the creator of a philosophical system like Descartes, who selected the facts fitting. I have come to doubt the sufficiency of this scheme from the fact that Stensen expressed caution against his alleged tool, inductive inferences.

Passages from the preface to *De glandulis oris*, dated Leiden 1661, exemplify the early Stensen pondering on the marvel of human imagination, the complexity of nature, the imperfection of knowledge, the inaptitude of reasoning alone:

> Among other things which, without understanding them, we reckon marvellous, the one which deserves the highest admiration is the capacity conceded by God to the human mind by which it recalls, whenever it likes, the images of things received through the senses. It sees in the image both absent things as if they were present, and all the parts that it observed in these things previously, with the same shape, size, colour, position in a much better way than if Protogenes, whose very rude sketches vied with the reality of nature, had drawn them from a living model ... For let us take the case of an old man who, eager to examine thoroughly the knowledge of natural

197. I am regarding the dissertation from Amsterdam, *On hot springs*, as an academic exercise, rather than as a scientific report.

198. Much the same thought is expressed in *De musculis*: "But it is an error to pronounce a thing impossible to be done because it seems so to us", Kardel 1986, p 109.

matters, spent his life in experiments, but enjoys vigorous old age. We marvel that through thought he traverses the huge universe extending over distances almost infinite and through the parts of this universe, inside a sphere of such small capacity, inside the skull. Flying up to the heavenly bodies he will explain to us the constant order of the fixed stars, the wanderings of the planets not known to deviate, the excursions of the comets lacking any law. From there, having fallen back in a moment, he will travel about the air and will depict pleasing varieties of colours, amazing forms of fires [lightning] showing themselves in these regions in intervals. Descending to the earth from there he will describe the different works of nature most carefully elaborated, which present themselves there, and the imitations of art that hardly yield to them. Finally, he will penetrate inside the earth and will reveal the concealed mysteries of minerals. All these ideas submits to his will, as if the macrocosm does lie hidden, contained within the microcosm. But although that effortless consideration of all the images which are received is wonderful, nevertheless the reception of single images, if they are going to represent an object faithfully, is to be expected only after much labour and difficulty, and hardly ever hoped for by anyone. For the mind, which seeks pleasure in variety, is indeed so impotent in the midst of all its power that, when it is occupied with the examination of objects, it cannot order itself to pay attention to a "this" nor indeed make itself empty of other thoughts so as to devote itself steadfastly to one idea alone. Moreover the subtlety combined with the multitude of parts of which natural bodies are composed is so great that it eludes and deceives even the most attentive. And thus, although in every age many have undertaken with the greatest labour and indefatigable study to make complete their idea of the structure of animals in all their numbers, why do we wonder that nevertheless it is still apprehended partly and imperfectly? ...

There are some people, I must say, who are convinced that an easier way is open for bringing about that knowledge about which we speak, so that there is no nead that everything be subjected to the external senses. They claim that reasoning alone can supply all the rest which is lacking ...

However great the power of the clever person to create new images by combining and separating those previously observed, and although nothing is easier for him than to conceive different causes for the same thing, where the matter itself remains silent, however, the clever person, whatever he says can only show, with the strongest arguments that such may well be the case but not that it is so ... The origin of the saliva confirms the same need of observations: reasoning deprived of the work of the senses did not find the paths carrying the saliva into the mouth. Neither will the paths which carry substances to the glands ever be expected from thinking alone.[199]

Stensen's early attempt in scientific epistemology was influenced, according to the *Chaos*-manuscript, by Galileo, Bacon, Descartes, and by Gassendi. Soon followed controversial discussions on scientific theories in *OPH* 4 and 13. Fully developed, the methods were applied and discussed in *OPH* 18, 22 and 27 and concluded in the *Prooemium, OPH* 31.

---

199. *OPH*, I: 2, pp 13 ff, translated by Paul Maquet.

3.1 Structural Part

In this and in the following sections I attempt an analysis of the constituents of Stensen's methods in science. As pointed out by Portal in 1770, within natural science Stensen preferred to describe the effects rather than to search for final causes.[200] He consistently tested a model or anticipation of Nature, derived from the literature and his own prior experience, against new observations. Any discrepancy triggered activity. From the writings we see that Stensen then checked the original source and attempted to verify the observation by repeating it in the same or in other biological species, or in the case of geology, at different locations. Like Galileo and Descartes and contemporary authors, he was concerned with the subjectivity of the senses: "I will ask them all with insistence not to trust too easily their senses. The senses indeed deceive us"[201] – thoughts expressed as early as in the first Hippocratic aphorism, "experience is fallacious". If upon renewed inquiry there was still a discrepancy, either he had observed something not yet described, or the model contained something without a basis in reality. This might be a structure not described previously, as in the case of the parotid duct; or a description in the literature of a structure differing from observation, as in the case of Descartes's description of a rotating pineal body of the brain.

The realist position of the practising scientist on the relation between an inside knowledge and the outside world and the subjectivety of the senses is expressed in the following sentence also from the *Prooemium*: "It is not the function of the senses to display things as they are – *res ut in se sunt* – or to judge them, but to transmit to the reason those conditions of the things to be examined, which are sufficient for acquiring a knowledge of things appropriate to man's purpose" (p 12).

In the letter to Thévenot,[202] Stensen presented "evidence for others to examine" on his method for the purpose of showing that "what I have said on muscle is true". He built upon:

(1) What is obvious to the senses, namely that;
(2) the observed structure is the same in different muscles, in different species, even when different methods of preparation were used.
(3) Explicitly, he searched for contradictory evidence. Since he had examined a limited number of animals and one human body only, he considered his proposal on the new muscle structure an opinion

200. Portal 1770, 111, p 173.
201. *Prooemium, OPH*, II: 31, p 251.
202. *OPH*, II: 22, p 97, Stenoon Muscles.

very close to truth – *ut opinionem vero maxime similem eam proponem.* Earlier I quoted almost identical words from an other work – Stensen must have found these thoughts worth emphasing. Then,

(4) explicitly he refrained from drawing conclusions on muscles from single observations, a decision mentioned already in the *Chaos*-manuscript (p 16) and reiterated many times.

Similarly in geology, Stensen looked at each specimen from different angles or searched for it at different locations. He was only satisfied when repeatedly he obtained the same answer. Stephen J. Gould has called one of Stensen's scientific criteria that of "sufficient similarity" exemplified by the following quotation from *De solido intra solidum*:

> If a solid body resembles another solid body in all respects, not only in the state of its surface but also in the internal arrangement of the parts and particles, it will resemble it also in the method and place of production.[203]

To obtain sufficient similarity a prerequisite is some kind of comparison. At the core of Stensen's applied method in science, repeated comparisons are the basis, hinted at in the above quotation.

As noted by Gosch, Stensen rarely repeated what others had found or said, and, I would add, what he himself earlier had written. Like Galileo and Gassendi he avoided dogmatism and was himself aware of his independence from authoritarian belief. He could hardly understand others who were dogmatic even in the face of conflicting evidence: "I have met several people who, even after having seen that both the substance and the composition of the heart is like that of the fibers of the muscles, nevertheless cannot bring themselves to acknowledge that the heart is a muscle, because they do not dare to depart from Galen, Descartes, and other authorities."[204] Autopsy, seeing for oneself, had been an element of the teaching at Copenhagen University. Stensen's use of this simple procedure to delineate conflicting evidence, i.e. earlier, unobserved or erroneously described structures, through repeated comparisons, forms the essential part of his scientific method to gain *knowledge*. Also, this ability once and again brought him within the threshold consciously of vast, unknown areas: *Ignorance* became an important consideration in his writings, expressed for instance in his two most famous sentences, both delivered in person to learned audiences: (1) the opening sentence from the lecture on the anatomy of the brain from Paris: "Gentlemen, instead of promising to

---

203. Gould 1981, p 24. The quotation is from *GP*, p 151.
204. *OPH*, II: 22, p 99.

satisfy your curiosity concerning the anatomy of the brain, I confess sincerely and publicly here that I know nothing about it"; and (2) in the opening lecture at Copenhagen, "beautiful is what we see, more beautiful what we know, but by far the most beautiful is what we do not know". Stensen's emphasis on ignorance, his faithful companion throughout research, links him spiritually with writers like Cusanus and his *De docta ignorantia*, with Montaigne's praise of ignorance, allowing Nature freedom to act,[205] with Sanchez's *Quod nihil scitur*, and with Socrates. But in the age of rationality such an approach was not prone to gain appreciation: "traces of the view that ignorance is sin are to be found not only in Locke and Berkeley but even in Hume", because, as Popper articulates this, ignorance stood opposite to truth, guaranteed by the origin of ideas, and ultimately supervised by God.[206]

3.2 The Instrumental Part – Dexterity

Dexterity in handling the scalpel in anatomical dissection combined with an exceptional visual acuity enabled Stensen to reveal tiny and fragile structures without damage. Several contemporary sources mention this skill. Thomas Bartholin did not himself dissect, but had his dissections mostly done by an assistant, Michael Lyser. Bartholin described Stensen as "a great Prosector, subtle of hand and modest in speech".[207] During Stensen's stay in Paris, a commentator in the *Journal des sçavans*[208] described his skill in dissection and how he presented the structures so convincingly that it was a wonder that they had escaped the attention of anatomists up to that time. Stensen's anatomical skill is also mentioned in letters by a French physician André Graindorge:

> When I called us apprentices compared to Mr Stensen, I was right. I have never seen such dexterity before. With his eye, the scalpel, and a little instrument turned toward the public in his hand, he lets us see what is worthwhile to remark on the structure of the eye.[209]

---

205. Høffding, 1894, I, p 27.
206. Popper 1979, *Objective knowledge*, p 68.
207. Cole 1944, p 369.
208. *Journal des sçavans*, 23 March, 1665, p 160:
> Ce sçavant Danois est presentement a Paris, où il fait tous les jours des dissections, en presence de beaucoup de personnes curieuses, & il en a fait dans l'Escole de Medicine, où il s'est fait admirer de tout le monde par ses nouvelles découvertes, car il a cela de particulier, qu'il rend la pluspart de ces choses si sensible, qu'on est obligé d'en demeurer convaincu, & d'admirer qu'elles ayent pû eschapper à tous les Anatomistes qui l'ont precedé.
209. 18 letters in the Royal Library, Copenhagen. Ny Kgl. Saml. 4660 4°. See also Scherz, 1969.

From their sojourn at Montpellier in 1665 Martin Lister made similar commentaries on Stensen's dexterity (section 1.6).

The most comprehensive first-hand description of Stensen's way of working in science is that of his student, Holger Jakobsen (Jacobæus), in the manuscript *Exercitatio academica*.[210] The unpublished diary of Stensen's dissection at Copenhagen in 1673, is edited here for the first time in translation.

3.3 Dynamic Part

"Very beautiful are those things which dissection draws forth from the hidden inner chambers, yet are not those things far more beautiful which, escaping the senses, are revealed through reason?"[211] Thus, the third part of Stensen's scientific method is the dynamic part, in which he developed and tested new scientific theories. One way was by entering a time scale into the description of structure, e.g. in 1669 by entering an age stratification into the distribution of layers of the soil. Similarly the description of a movement is a description of structural changes related to time. Stensen described a structure versus time relationship in a model, *mensura*, of muscular contraction in *Elementorum myologiæ specimen*.

When testing a theory with a time-relation, a match between anticipation and observation entails support of the theory, while a discrepancy falsifies it. Testing a time-related theory in this way is performed by series of matchings. In Stensen, a requirement of identity was to be met by his own theories as well as those of others reported in the literature.

Stensen also formulated lesser theories, without using a time scale or mathematical model, by putting together observations. For example, he proposed that ear wax is secreted by glands he observed along the auditory meatus; that tears come from well-known glands behind the upper eyelid and not from the brain along the optic nerves, this in spite of the small size of the glands in the eyelid and the ample supply of water in the brain; that milk is filtered from arterial blood and derived neither from the thoracic duct nor from the veins, in spite of the milk-like *chylus* contained by the thoracic duct, and the fact that veins are seen swollen in a lactating breast. Such statements were

---

210. Royal Library: Ny kgl. Samling 309 *aa* 4°. *OPH*, II: 36, pp 287-310.
211. *OPH*, II: 31, p 253.

(and still are) possible to falsify. Stensen himself tested the theory of milk-secretion by an experiment in a lactating dog.[212]

Stensen's most comprehensive theory in biology is that of the compartmentalisation of the fluid space in the living animal, briefly mentioned in some of the studies on glands and in the Thévenot letter related to muscles,[213] and presented in great detail in *De solido intra solidum* as a general theory.[214] The completeness and originality of this first description still awaits appreciation. It is reprinted here in full from the 1671 English translation by Henry Oldenburg, the secretary of the Royal Society of London (Fig. 13).

Steno on Compartmentalisation of the Water Space in the Living Organism

Excerpt from Prodromus to a Dissertation Concerning Solids Naturally Contained within Solids

Besides a Subtil fluid pervading all, we observe at least *three* sorts of Fluids in Animals, of which the first is *External;* the second, *Internal* and *Common*; the third, *Internal*, and *Appropriate* to each part. <p 28>

By the word of *External* Fluid in Animals I understand not only that, which encompasseth the visible surface like an Atmosphere, but that also, which toucheth all the other surfaces of the Body that by the greater holes are continued to the said surface; such as are, the surface of the *Aspera arteria* or Wind pipe, which the Air inspired toucheth; the whole surface of the way of the Aliment, by which I mean the Mouth, the Weasand, the Stomach, and the Entrals; the whole surface of the Bladder and the *Urethra*; the whole surface which hath communication with the Womb, at least in the years of ripe age; the whole surface of all the excretory Vessels, continued from the capillaries unto the orifices, which discharge their contents into the Ears, Eyelids, Nostrils, Eyes, the way of Aliments, the Bladder, the *Urethra*, the Womb, and the Skin; the particular enumeration and description of which would show, that many are indeed extrinsick, which are esteem'd intrinsick, and even inmost, by the Vulgar; and consequently, <p 29>

1. That the Worms and Stones generated *within* our Body, are most of them produced in the *external* fluid.

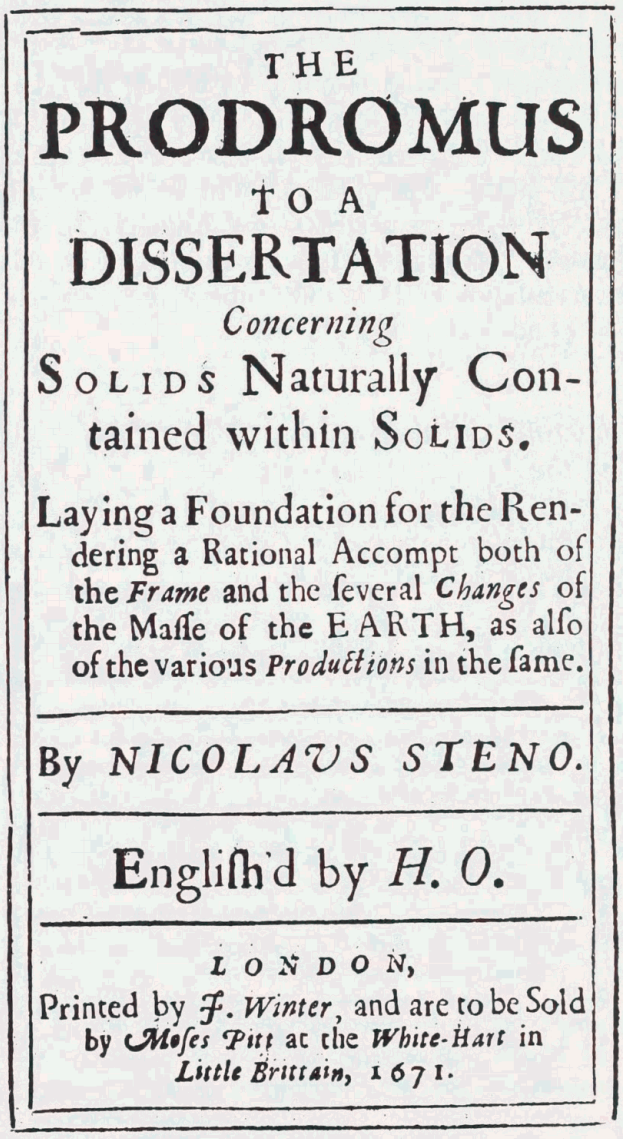
2. That divers parts are necessary to Animals, because they are there, not that the Animal could not *be* without them.

---

212. *OPH*, I: 2, pp 47-48.

213. *OPH*, II: 22, p 103.

214. A Danish tradition in capillary and in fluid and solute regulation research may have taken its departure from Stensen's *De solido intra solidum*, because this work was translated into Danish by August Krogh and Vilhelm Maar (Steno 1902). In 1920, the zoo-physiologist August Krogh (1874-1949) received the Nobel Prize for studies on capillary physiology. However, I found no reference either in Krogh, or in the historical survey, "Træk af kapillærfysiologiens udvikling", by the physiologist Christian Crone, Copenhagen 1974.



THE
PRODROMUS
TO A
DISSERTATION
Concerning
SOLIDS Naturally Contained within SOLIDS.

Laying a Foundation for the Rendering a Rational Accompt both of the *Frame* and the ſeveral *Changes* of the Maſſe of the EARTH, as alſo of the various *Productions* in the ſame.

By *NICOLAUS STENO.*

Engliſh'd by *H. O.*

LONDON,
Printed by *J. Winter*, and are to be Sold by *Moſes Pitt* at the *White-Hart* in *Little Brittain*, 1671.

Fig. 13. Title page from *The Prodromus to a Dissertation Concerning Solids Naturally Contained within Solids*. Englished by *H. O.* (Henry Oldenburg).

I call the Fluid, which toucheth these surfaces, *External*, because it communicateth with the ambient fluid by channels without any intermediate capillary Vessels, that is, without percolation or straining: whereby it comes to pass, that though the cavities, containing the said fluids, be sometimes shut, yet as often as they are open'd, they discharge all the parts of the retain'd Fluid without discrimination.

I call that Fluid *Internal*, which hath no communication with the *External* fluid, but by the intermediate strainers of the Capillary Vessels, and therefore naturally never transfuseth all its parts into the outward Fluid without some difference.

<p 30>

The *Common* internal Fluid is that, which is contained in veins, arteries, and Lymphatick Vessels, at least those, which are betwixt the conglobate[lymphatic] glenduls and the Veins intercepted. I call this fluid *Common*, because it is distributed towards all the

parts of the Body. Of that other Common Fluid, which is contain'd in the Nervous substance, since 'tis less known, I determine nothing.

An *Appropriate* internal Fluid is that, which is circumfused about the capillary Vessels of the *common* Fluid, and is different according to the diversity of places: for there is another in the sanguineous *parenchyma's*, another in the exanguious ones; another, about the moving fibres; another, in the Egg-shell; another, in the substance of the Womb; another in other places. Nor is that Opinion agreeable to Reason or Experience, which holds, that the extremities of the Veins and Arteries terminate in every the smallest particle of the Body, for the distribution of warmth and food to them all; but there are every where cavities, into which the parts sever'd from the blood are mixed with the Fluid of that place, and thence to be added to the solid parts; as again the Particles worn <p 31> off from the solid parts fall back again into those hollownesses, to be again restored to the blood, and thereby to be conveyed away to the external Fluid. The Fluid of theses cavities is in divers things consonant to the Doctrin of the great *Hippocrates* concerning *Flatus's*: Although I am not able to determine, why in divers places from the same blood are discharged different Fluids; yet I hope that there wants but little for the determination of it, in regard 'tis certain, that that depends not from the Blood, but from the Places themselves; the consideration of which may be included in these three particulars.

First, By considering the Capillary vessels of the *common* internal Fluid; which is alone heeded by those, who ascribe all to the percolation through divers Pores; of which number I once was my self.

Secondly, By considering the *Appropriate* internal Fluid; about which alone those are conversant, who attribute to every part a peculiar Ferment; whose Opinion may be true in part, though the word *Ferment* depend on a comparison taken from so peculiar a thing.

Thirdly, By considering the Solid of every part; to which those adhere chiefly, who by attributing to each part its forme, do intimate that they acknowledg there to be something proper, which yet is unknown to us; and which according to that knowledge of matter, that we have hitherto obtained, can be nothing else but a Porous surfce of that Solid, and a subtle Fluid permeating those pores.

I should too much wander from my subject, if I should apply the things, I have discours'd of, to what daily happens in our Body, and cannot be rationally explicated otherwise. It may be sufficient to have hinted here, that the Particles, which do many ways part from the external Fluid, are carried into the internal Fluid, by the means of Percolation; whence being likewise variously sever'd, and by a new cribration transmitted into the Appropriate internal Fluid, they are added to the solid parts, either by way of Fibres, or Parenchyma's, according as they shall have been determin'd by the to us yet unknown propriety of every part, included in the consideration of the three lately mention'd particulars.

The aim of this account is found in the author's point 1: that worms and stones are generated mostly outside the body itself in the socalled *external* fluid, likewise to crystals, elsewhere in the treatise postulated to be produced in waterfilled caves in rocks. Stensen's division of the fluid into communicating external and internal fluids with a subdivision of the internal fluid into a common internal (=intravascular) fluid and an appropriate internal (=extravascular) fluid, the latter being separate in the various organs in the body, seems not to have been recorded by other scientists.

3.4 Introduction of Mathematical Methods in Biology

The introduction of a model, *mensura*, of the structure of muscle enabled/required Stensen to apply mathematical methods to describe the motion of the living organism. This was formulated as a general programme in the preface to *Elementorum myologiæ specimen:* "I do wish to demonstrate in this Specimen that unless Myology becomes a part of Mathematics, the parts of muscles cannot be distinctly identified nor can their movement be successfully studied." While the credit of re-introducing mathematical analysis in the study of astronomy and physics goes to Kepler and Galileo, and in the study of optics to Descartes, Stensen deserves recognition for his early application in biology as suggested by the *Philosophical Transactions of the Royal Society* in its review:

> The Author of this Book declareth, that his design in composing it was, to shew, that in a Muscle neither the Parts of it can be distinctly named, nor its Motion duely consider'd, unless the Doctrine thereof become a part of the Mathematicks. And he is of opinion, that there is no other cause of the many Errors, which spoil the History concerning the Humane Body, than that Anatomy hath hitherto disdaind the Laws of the Mathematicks. And therefore inviteth those that are studious in that part of Philosophy, to consider, that our Body is an Engine made up of a thousand subordinate Engins, whose true knowledge whoever thinks that it can be investigated without Mathematical assistance, must also think, that there is matter without Extension, and Body without Figure.[215]

3.5 Expressive Part

The fifth part of Stensen's scientific method is the highly esteemed way in which he formulated his research in eloquent and masterfully illustrated reports,[216] integrating observations with reasoning:

> To satisfy the laws of analysis to the best of my ability, I wove and unravelled the web of this investigation many many times, and examined its individual parts until there seemed to me to be left no further difficulty in the reading of authors, neither in the objection of friends, nor in the inspection of sites, that I had not either solved, or about which I had at least decided, from what I had learned already, how far a solution was possible. (*GP*, p 143).

---

215. *Phil Trans*, 1667, vol. 2, p 627.

216. Burke, p 161. Kragelund, p 239. Snorrason, 1986, pp 191-209. Stensen gave a programme for using correct illustrations in *Discours sur l'anatomie du cerveau*, *OPH* I: 18, p 24:

> Apres que l'on auroit fait un plan veritable, & tres-exact, des parties du cerveau; découvert les erreurs, avec leurs causes; & arresté le vraye maniere de démonstrer ces parties, en usant de toutes les precautions necessaires: il faudroit encore tâcher d'exprimer ce que l'on auroit connu, par des figures iustes & fideles; car il vaudroit mieux n'en avoir point, que d'en avoir de fausses ou d'imparfaites.

Often Stensen's reflections reach the character of aphorisms like in the following four examples. In the *Prooemium* he outlines a distinction between Nature, *Natura*, and world, *Mundus*:

> The world only promises more and greater things than it offers; Nature offers more and greater things than it promises. Strictly speaking, both are deceitful, since with both, what lies hidden is different from what appears.

Also from the *Prooemium* on the recognition of the pathological and normal state:

> The recognition of an extraordinary state cannot extend beyond the knowledge of its natural state.

In the introduction to *De musculis et glandulis* Stensen described the complementary relation between the detail and the whole in research:

> It is proper to scientific research that one cannot keep the various areas so isolated from each other as not to be obliged to bring many of them into one's consideration at the same time. The longer you stick to the details the more elements you lack in the whole.

The closing remark in the *Discours* demands team-work in research:

> We shall always be miserable ignorant if men most suited to research work fail to combine their labours, their industry and their studies.

The exacting care of Stensen's written expression is evident from close to one hundred tiny to extensive changes in his own hand in the printer's manuscript of the *Elementorum myologiæ specimen* (Fig. 14).[217]

In the interpretation of a text, confusion can arise from ambiguity in words. This problem was addressed in the *Discours*.[218] In the Letter to Thévenot, Stensen tackled the ancient roots of some words: "I leap over the confusion arising from the use of phrases like the beginning, the end, the connecting link [ligamentum], the stretching part [tendo], and other terms destined to express parts of the muscle, which are arguments making evident that the thing itself is not well known" (*OPH*, II: 22, p 103). In *De solido intra solidum* we see the same care to express a message by specifically explaining the meaning of the words used:

---

217. E.g., *non eam proponam tantum ut opinionem maliis veram* was changed by Stensen to *ut opinionem vero maximè similem eam proponam*, expressing the same idea but eliminating a double negation. *OPH*, II: 22, p 98.

218. *OPH*, II: 18, p 14:

> Il est encore arrivé, que ceux qui ont entrepris de faire ces explications, par ie ne sçay quel esprit, qui s'est rencontré en la plus-part de ceux qui ont écrit des arts, ont employé des termes fort obscurs, des metaphores, & des comparaisons si peu propres, qu'elles embarassent presque également, l'esprit de ceux qui entendent la matiere, & de ceux qui s'en veulent instruire.

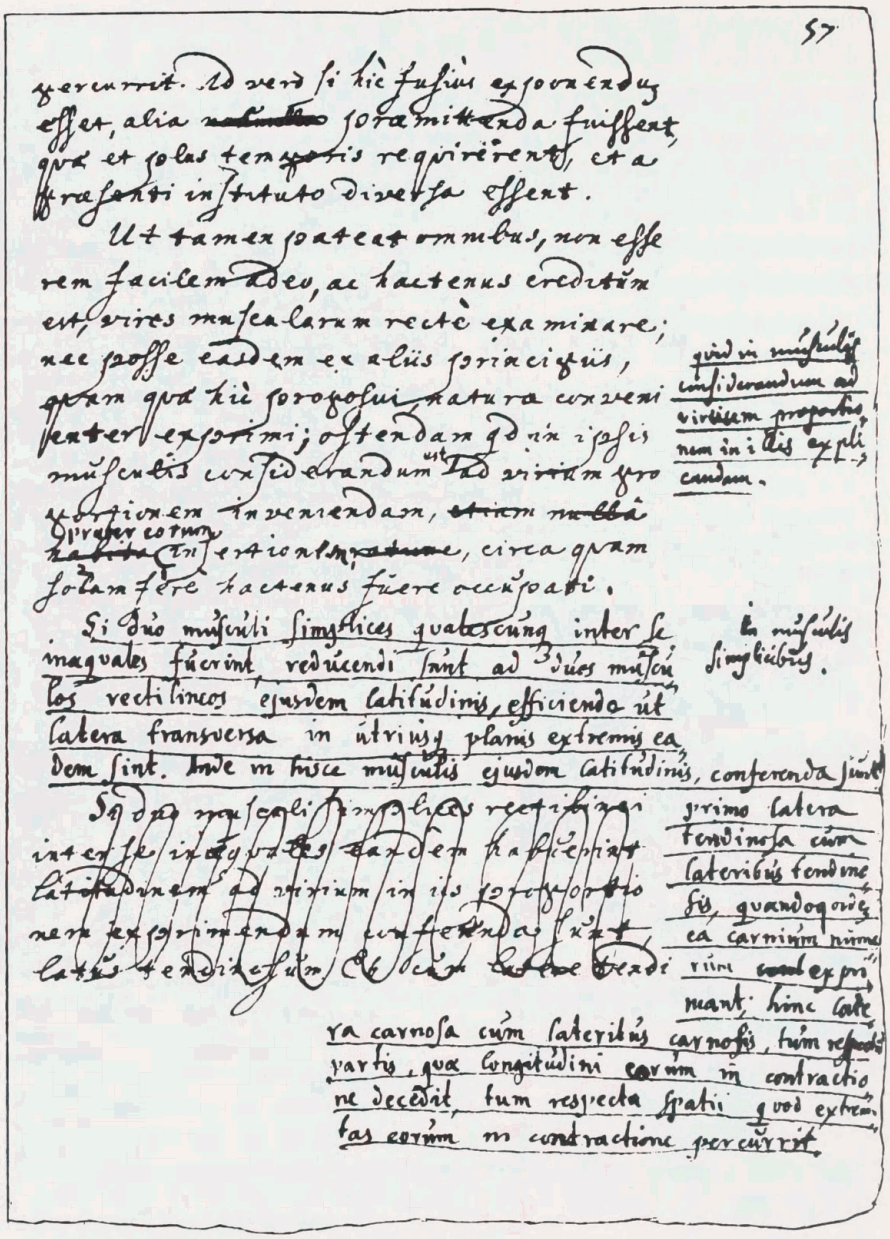


Fig. 14. A page from the printer's manuscript of *Elementorum myologiæ specimen* with Stensen's corrections. Royal Library, Copenhagen.

> Here, before going on to expound the solution to the problem, I strive to set down the meaning of all the terms in it, so that no school of philosophers may be left in doubt and dispute about them ... Following this, I explain the various modes of speech that are commonly accepted through usage, by which we explain in various ways the diverse production of different bodies, and sometimes of the same bodies. (*GP*, pp 141 and 147).

In the letter on a calf with hydrocephalus written in 1669 Stensen made a similar effort:

> Truly in order to provide a clear description of an abnormal state in an organ, in which the normal state has yet to be explained sufficiently, it would be appropriate to begin by specifying the parts of the brain which I intend to discuss and to give them names suitable for everyone's understanding. (*OPH*, II: 28, p 230).

In the second section of *Antilogia*, a late theological work from 1684, Stensen likened the arbitrariness of the meaning of words to that of the value of coins, having whatever value they are given.[219]

From the scientific publications and from the letters, it is evident that Stensen mastered Latin, French, Italian, and German.[220] During three years in the Netherlands he must have learned Dutch. Quite often he used Greek phrases especially in his early writings, and he studied theological works in Hebrew (*E* 36). Some broken fragments of texts written in half English half Latin in Stensen's hand exist.[221] The latest of these notations were written after the publication of a listed work: "Mayow de respiratione et Rachitide. Oxon. 1668". Only two letters are preserved in Stensen's native Danish.[222]

In a letter in Italian, recently recovered by Niels W. Bruun, Stensen

---

219. *OTH*, I, p 487.

220. Cf. Rosen, pp 134 and 145. Knud Larsen, in a note to the former, drew attention to a remark by Fabroni 1775, p 27, that Stensen in his studies of the Scriptures in Italy made use of Greek and Hebrew manuscripts, not exclusively relying on the Latin translations.

221. *Posteriori di Galileo*, Tomo 32. Academia del Cimento. Parte III, Carteggio Vol. 17: Scritti di Niccolò Stenone. Biblioteca Nazionale Centrale, Florence:

"Salt and Brimstone, cujus pulvere springwater reddish purple"
"rattle snack in V. occiditur, odour, by the scent of a wild ... royal or ... of Virginia. in Scotia quibusdam in locis the Coal is some 18 or 20 foot thick.
brimstone and vitriol a Liège."
N. B. Boyle de frigore.

"A. 1665. Mart.
Vitulus bilinguis, duabus sitis ad latera oris, – the under leggs absque joints, lapide $20^1/_2$ librarum, sito inter pedes anteriores et posteriores. exterius virescens, plenus ... foraminolis, interius Free stone... p 20"...
"minera Lead ore ex low Palulinati [?] superioris Freyung [?]"
"Balenas circa Bermudas ferociores" ad Weedbeds of the gulf of Florida. upon their fins and Tails, Claws or Barnacles, upon wich Rock-weed or Sea-tangle a hand long, of the bignes of great oystershells.

(The transscription by help from A. Ziggelaar).

222. *E* 75 and 108.

is pondering over the meaning of a translated book even if the original language is close to that of the interpreter.[223] And in *OPH* 4, is found the following comment on translating: "a good interpreter considers not only the words as such but also compares them with what precedes and what follows. When dealing with a matter, it is better to explain all that the author means than to present his words as such unless one adds, if need be, at what occasion the words were pronounced."

Several times Stensen makes excuses for his spoken expression. He may have been overcritical, but my suggestion is that he was not a very good speaker. Why? I doubt that many in the audience understood his lecture *Prooemium*, in spite of being well trained in Latin, because of its extremely complex and circumstantial language. The *Discours* is much easier to read. But how did these lectures sound? Oddly enough, primary sources do not deal with this. Stensen's forte was anatomical demonstrations in small groups and the written presentations.

3.6 Approaching Truth through Demonstrative Certainty

Stensen's writings noticeably prescind from metaphysical statements, reflections on final causes, generalizations based on single observations and euphonious analogies, at a time when such arguments were prevalent in the scientific literature. The reason for this, I would maintain, is that Stensen's concept of truth and certainty differed from that of many of his contemporary scientists.[224]

As far as I see it, *truth*, can either mean conformity of a notion with reality *or* some notion intuited *a priori*. In his scientific writings, Stensen seems to restrict the meaning of truth to conformity with reality, and even tended to identify truth with reality:

> Let observation approximate reason, as it should, and, as much as it is permitted, let the thing itself be examined in all its parts, so that the image displaying the thing to the mind may be assigned in a true way.[225]

---

223. Bruun 1992, *Zu einem neuen Niels Stensen-Brief*.

224. In the *Discours*, *OPH*, II: 18, p 6, Stensen made a comment on whether erroneous descriptions in science are made deliberately:

> I'ay trop bonne opinion des hommes de lettres en general, pour croire qu'ils le fassent avec dessein de tromper les autres; les principes qu'ils se sont establis, & la maniere de dissection à laquelle ils s'assuiettissent, ne leur permettent pas de faire autrement. Tous les Anatomistes les demonstreroient de la mesme façon, s'ils se servoient tous de la mesme methode. Il ne faut donc pas s'estonner si leurs systemes se soustiennent si mal.

225. *OPH*, I: 2, p 15. See also the preface to *De solido intra solidum*: move towards true knowledge through experiments – *ad veram rerum cognitionem per experimenta incedunt*, and, certain tokens of an unknown truth – *veritatis incognitae indicia*, *GP*, pp 136-37.

Stensen did not base certainty on authoritative – *ex auctoritate* – statements, but as exemplified on observations and experiments: "reasoning helped by the action of the senses makes it certain",[226] and observations were always repeated: "these matters were not observed one day only, nor were they seen in one subject only"[227]. Thus, my interpretation of Stensen's use of the words truth and certainty in the scientific writings differs from that of Scherz who wrote: "[Stensen's] philosophical attitude, first of all [was] characterized by his methodological and unremitting efforts to attain certainty based on truth and truth based on certainty."[228]

The researches of Copernicus, Bruno, Kepler and Galileo in astronomy and physics, and of Vesalius and Harvey in anatomy and physiology, had challenged the scholastic system, in which knowledge and thereby truth was derived from the Scriptures, and from Aristotle, Ptolemy, Galen, and other ancient authors. From observations scholars learned to doubt the old truths; through reasoning, their eyes were further opened to errors. But in creating new systems natural philosophers tended to build deductive systems from new truths. Scholars learned from Descartes that everything was to be doubted, but sufficient care was not taken by Descartes's followers to question new systems and to test them.[229] The concept of approaching truth in striving for demonstrative certainty became the norm for natural scientists through a learning process.[230] Stensen is one of the pioneers in this process in biology and geology, in practice by his findings in research, and in theory by sentences in passing, like the following from the *Discours sur l'anatomie du cerveau*:

> One cannot act the sage and acknowledge one's own ignorance at the same time. For my part, I prefer to acknowledge my ignorance rather than utter authoritative opinions whose falsehood will be demonstrated by others at some later date. We have seen great anatomists fall into such trouble and we observe others, besides, who imagine

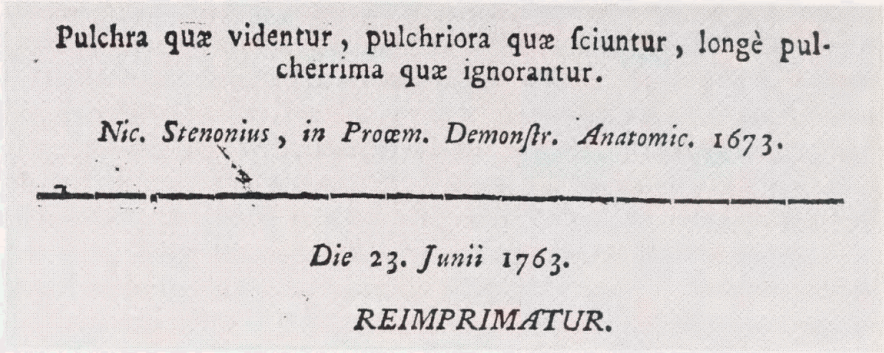
---

226. *OPH*, I: 15, p 181.
227. *OPH*, I: 15, p 192.
228. Scherz (ed.), 1968, p 296.
229. Stensen commented on contemporary scientists' blind acceptance of Descartes's earthen machine in *Discours sur l'anatomie du cerveau*, *OPH*, II: 18, p 8:

> Ie me serois contenté de l'admirer avec quelques-uns, comme la description d'une belle machine, & toute de son invention; si ie n'avois rencontré beaucoup de gens qui le prennent tout autrement, & qui le veulent faire passer pour une rélation fidele, de ce qu'il y a de plus caché dans les ressorts du corps humain.

230. Mazzolini 1991, p 71:

> This love of criticism and a veneration of detail were to counsel many of the anatomists of the sixteenth century to greater caution, and this caution was soon to become a daily habit and the very mark of the profession. This is the circumspection that was typical of Steno at the end of the seventeenth century, or of Haller in the century to follow.


Pulchra quæ videntur, pulchriora quæ ſciuntur, longè pulcherrima quæ ignorantur.

Nic. Stenonius, in Proœm. Demonſtr. Anatomic. 1673.

Die 23. Junii 1763.

REIMPRIMATUR.

Fig. 15. Motto in the fourth (out of six) Italian editions of Winslow's *Anatomy*, Napoli 1763.

> that men should have more faith in their obstinate opinions than in visual evidence. I leave such self-conceit to those who delight in it; I try to follow the laws of philosophy that urge us to search for truth by doubting its certainty and by being dissatisfied with it until we have confirmed it by the evidence of a demonstration.[231]

Countering philosophical as well as scientific dogmatism, Stensen here expresses a constructive scepticism in search for truth by doubting its certainty.

Stensen's position was summarized in the lecture that he delivered in 1673 at Copenhagen:[232]

> Indeed to defend this pursuit of the truth to the best of my ability, conscious of the easy risk of error, and to avoid the mistakes committed by others, I will not keep to experiments alone nor bring forward arguments alone, but I will seek such a mixture of both that, by the reckoning of everyone, if not most, at least much will possess a demonstrative certainty.

Commentators have tended to interpret the Socratic[233] "ignoramus" of the middle of the *Prooemium*, "beautiful are the things we see, more beautiful the things we know, but far more beautiful the things we do not know" (Fig. 15), as expressing the three stages of Thomas Aquinas (1225-1274) in coming to know God.[234] Less attention has been de-

---

231. *OPH*, II: 18, p 23. Translation by Alexander J. Pollock.
232. *OPH*, II: 31, p 256. This position has been formulated, not unlike Stensen, by a practicing scientist of today, Peter B. Medawar:
> The purpose of scientific enquiry is not to compile an inventory of factual information, nor to build up a totalitarian world picture of natural Laws in which every event that is not compulsory is forbidden. We should think of it rather as a logically articulated structure of justifiable beliefs about nature.
233. Scherz 1968, p 298.
234. Billeskov Jansen 1986, p 23. See also Nolte 1986, p 82:
> Diese Devise [pulchra sunt ...] umfasst exakt die von Stensen angegangenen Erkenntnisgebiete des Körperlichen, des Geistigen und des Göttlichen ...

voted to the culmination in the final paragraphs, in which at the close of his short scientific career, Stensen asserted that it is the aim of science to gain access to the beauty beyond senses and reason, neither by experimentation alone, nor by reasoning alone, but by seeking a mixture of both.[235] Thus, when read in its context, the famous[236] "longe pulcherrima, quæ ignorantur", captures two things at the same time, firstly what is not yet known, secondly what cannot be known.[237] Meanwhile, in the original edition, *the paragraph ahead of* but not the famous sentence itself, is emphasized by *italics*. I may add a conjecture on sources which might have triggered Stensen's famous remark: (1) "for there are indeed a great many who openly confess that the greatest part of those things which we do know, is the least of the things which we know not"; and (2) "although many things have been discovered by the learned men of the former time, yet do I believe that far more still remains concealed in the darkness of uncharted Nature". The former sentence is from the Epistle Dedicatory of *De motu cordis*, the latter from the Prefatory Epistle to *De generatione*, by William Harvey.[238] Scepticism re-emerged as a theme in biology in the late 19th century, when taken up by the influential German physiologist, the religious agnostic, Emil Du Bois-Reymond (1818-1896). Considered then destructive to science by "expansionists", his *ignorabimus*, "we will never know", aroused decades of heated debate among continental scientists.[239]

The *Prooemium* contains a key to the understanding of differences between the position of Stensen and those of system builders like Bacon, Descartes, Spinoza, and Leibniz, and it serves as well as a bridge between Stensen's methods and those of modern scientists.

---

235. A similar expression is found in the preface to *Elementorum myologiæ specimen*, *OPH*, II: 22, p 64:

> And why would it not be permitted to hope for great things, if Anatomy was transformed so that experimental knowledge would rely on well established facts only and reason accepted what has been demonstrated only; in other words, if Anatomy used the language of Mathematics.

236. Winslow quoted the sentences as motto for his *Anatomy*, printed in numerous editions and five translations. Goethe: *Pulchra sunt quae videmus, Quae scimus pulchriora, Longe pulcherrima quae ignoramus*, in "Zur Naturwissenschaft überhaupt, besonders zur Morphologie", Stuttgart und Tübingen, 1820. Cf. Heinrich Roos, 1957. The late Danish author Elsa Gress used the sentences as motto for her "Fuglefri og fremmed", Copenhagen 1971. Her aberration, *pulchra videntur, pulcheriora intelligentur, pulcherrima ignorantur*, was a quote from memory (personal communication).

237. Cf. Bierbaum & Faller, p 28.

238. Both quotations are from Gweneth Whitteridge's translation of Harvey's *The movement of the heart and blood*, p 6 and 8.

239. Johnsson 1985.

"I do not therefore reproach Descartes for his method, but for ignoring it,"[240] was a late comment by Stensen in 1680. Early in his period as scientist, in a letter to Thomas Bartholin in 1661,[241] Stensen critically exposed the consequences in vivisection of the Cartesian idea that animals have no soul, and that animals can therefore feel no pain: "but I admit that I cannot without horror subject the animal to these lengthy torments. The Cartesians boast so much of certainty in their philosophy – I would wish they could make me as sure as they are themselves that animals have no souls and that one may touch, sever, or burn the nerves of an animal with the same indifference as if it were an automaton moved by artifice." The arbitrary base on which Descartes, and even more his followers, built a deductive system was at issue.[242] The same question was raised by Stensen on Spinoza's method, "because your philosophy deals with the soul through a system formed on suppositions".[243] This early criticism from a practising scientist on the methods of Descartes and Spinoza seems largely to have escaped the attention of philosophers of science.[244]

Stensen was no less critical of the scientific foundations of medical practice:

---

240. *In Cartesio itaque non methodum repraehendem, sed methodi neglectum. OTH*, I, p 390.

241. *E* 3. Translation from Billeskov Jansen 1986, p 16.

242. In Gorham, 1994 p 234, Descartes's reason for regarding animals as soul-less was partly religious, at least the ascription of mind to animals would not have been inconsistent with his physiology. Stensen's critical attitude toward the teaching of Descartes is exemplified by several quotations collected by Faller, 1958, and by Scherz, 1963 pp 272-75. In particular see *E* 65, Stensen's letter to Malpighi 24 November 1671 (German translation, Scherz, 1963 pp 314-8) in which Stensen questioned how the soul, being of a spiritual nature, can feel a change in the body. Stensen's unfinished writings on the relation between matter and soul is found in the *Addendum*.

243. *..., tum quod philosophia tua cum anima agat per systema ex suppositis formatum, ...* Stensen's letter to Spinoza, *OTH*, I, p 95 = *E* 61.

244. The exception among philosophers, Auguste Georges-Berthier (quoted p 37), discussed Stensen's relation to Descartes. Georges-Berthier wrote:

> Mais non moins mécanique est celle d'un critique du cartésianisme comme Stenon, tout pénétré de l'esprit de la nouvelle physique et qui, par sa méthode géométrique comme par l'essentiel de sa théorie du mouvement musculaire, s'accorde avec Borelli, qu'il dépasse par sa claire conscience de la nécessité de la jonction – tentée déjà par son maître Sylvius – entre la chimie, l'anatomie et les mathématiques. (*Isis*, vol. 3, p 29).
>
> Sans doute, on ne peut méconnaître la liaison immédiate qui existe entre la conception que Descartes se fit des êtres vivants et son dualisme, qui semble transformer en certitudes démonstrées ces "suppositions" dont parle Malebranche et infirmer notre interprétation, déjà entrevue au XVIIe siècle par Stenon, jugeant que Descartes ne cherche pas à atteintre la vraie et réelle structure de l'homme, mais se contente de décrire une machine capable de remplir toutes les fonctions dont l'homme est capable. (*Isis*, vol. 3, p 51).

> They all look for remedies and for that part to which the remedies apply, but few attempt to understand. But just like the construction of a machine built by someone else must be precisely understood by the one who must restore this damaged machine, similarly the nature of the blood, and the nerve fibre, and of the motor fibre must be investigated as far as human zeal permits by the one who wishes to cure not only by luck the symptoms affecting the natural movement.[245]

Nor did the empiricists escape his attacks:

> Even the advocates of experience have rarely had the restraint either to avoid rejecting entirely even the most certain principles of Nature or to avoid considering their own self-contrived principles as proved.[246]

As remarked, he touched upon the problem of induction: "... who did assure you that experiments contrary to this opinion could not be shown, given time".[247]

Stensen closed his last work published in science by questioning the necessity claimed by modern authors which is possibly a hint at Spinoza:

> This imperfect description of the muscles, perhaps not without its own errors, is no less boring to readers than their preparation has been delightful to observers; the most elegant, skilfully crafted structures very often met in them are indeed only obscurely described in words. But the flesh revealed to the eyes by the course of its fibres, the colour of the tendons, the proportion of the insertions and the distribution of its trochleae they surpass all admiration. If it be God's will that I complete the Myology of the many animals already begun, what now appears to be a sterile study will be abundantly fruitful, and by means of this the true causes of discrepancy in the outer shape of different animals are to be understood; then by which the mechanical artfullness is to be brought to light, indeed, especially to defend the freedom to act of the universal cause against necessity claimed by modern authors, who, while in the trickery of their arguments seem to take away all freedom, themselves in the choice of the most exquisite charming words too often use the greatest liberty, and thereby destroy in fact what they try so laboriously to ascertain by words.[248]

---

245. *Steno on muscles*, p 225.
246. *De solido intra solidum*, *GP*, pp 144-45. I have changed the translation of [experientiæ patroni] from [advocates of experiments] in Alex J. Pollock's translation to [advocates of experience]. This change is in accordance with Henry Oldenburg's translation from 1671. In the Danish translation by August Krogh and Vilhelm Maar (1902, p 13) the same passage is translated as follows: "Selv den empiriske Metodes Talsmænd har sjældent vist saameget Maadehold, at de ikke enten har forkastet alle, selv de sikreste, Teorier om Naturen eller ogsaa har anset de af dem selv udfundne Teorier for beviste."

    Scherz, in note 24 to the English translation, targeted Stensen's critical remark differently: "It is obvious to think of Descartes in this connection."
247. *OPH*, I: 4, p 64.
248. *Dissection of an Eagle*. *OPH*, II: 32, p 277. Translated by Sister M. Emmanuel Collins.

Stensen, as his point of departure for scientific enquiry, rarely began with a *tabula rasa*, an empty slate, but, as a rule, compared observations with his anticipation – some earlier source of knowledge.[249] The significance of an observation was not framed in absolute terms, but was determined by reliability on repetitions.[250] In addition, modes of analysis and communication, going beyond mere observation, involved comparisons of structure versus function, structure versus time, or function versus time with mathematics being the language of communication. Without losing his admiration for the Creator for the beauty of the creation, Stensen is an early exponent of researchers describing biology in terms of dynamic processes without adding speculation on final causes.

Typical for Stensen's dynamic approach in science is his study of crystallography: Stensen did not describe the angles of crystals; but he applied geometrical methods to show that the angles do not change when crystals grow.

Stensen's drive for research was stimulated by a persistent curiosity to obtain insight into the mechanisms of Nature, rather than by lust for influence.

Stensen made reference to classical scepticism in the introduction to *De solido intra solidum*, when he compared his scientific task with an apparently impossible one: "Democritus made use of a good example of a well in which, since both the number and size of the hidden springs leave the quantity of material flowing into the well in doubt, a proper estimate of the work and time involved in emptying it could scarcely be made except by draining the well dry".[251] And staying in Greek scepticism he continued:

> I might liken these doubts to the heads of the Lernean Hydra, since when one was destroyed, countless others grew out from beneath; at all events, I saw that I was wandering in the kind of labyrinth where the nearer one comes to the exit, the greater the circles in which one walks.

---

249. My interpretation differs from that of Garboe, 1958 p 106:
> He simply took the objects before him and described what he saw, forgetting all "learned" thoughts, and he rapidly arrived at his own epoch-making understanding of the problems. A path on which others could walk was opened.

250. "La premiere chose qu'on y doit considerer, est l'histoire des parties, dans laquelle il est necessaire de determiner, ce qui est vray & certain, pour le pouvoir distinguer d'avec des propositions, qui sont ou fausses, ou incertaines. Ce n'est pas mesme assez de s'en pouvoir éclaircir soy-mesme, il faut que l'évidence de la demonstration oblige tous les autres à en demeurer d'accord; autrement le nombre des controverses augmenteroit, au lieu de diminuër." *OPH*, II: 18, p 19.

251. *GP*, pp 137 ff. The quotation from Democritus was identified by J. L. Heiberg (1854-1928) to be from Diogenes Laertius, Pyrrhon, IX, p 72. Cf. *GP*, p 220, note 2.

But Stensen took up the task and presented his preliminary results:

> as a token of my gratitude for the favours I have received, and to provide an opportunity for others, who from their own wish have the use and enjoyment of leisure, to cultivate studies in physics and geography with greater profit.

However, neither proof of abundant errors in contemporary teachings, nor the subjectivity of senses made Stensen a fundamental sceptic, because, as I see it, from his own experience he had learned how to ask questions of Nature, and how to interpret the answers. By repeating and slightly changing the questions, Stensen evaluated the reliability or certainty of answers.

Probability is mentioned being considered incomplete certainty caused by the limitation to induction:

> Reasoning convinces us that all this must be considered as true, since it is proved by the testimony of the senses. On the other hand, the following propositions [that glandular secretion is a filtrate from arterial blood] must be considered only as probabilities. They are arrived at by induction even if this induction is not complete for all points.[252]

Scherz used the following quotation from *Canis carchariae* as an example of Stensen's methodological doubt:[253]

> I do not yet have the knowledge of this matter to pass judgement on it here; and though my travels have taken me through various places of this kind, nevertheless, I do not dare to guarantee that what I shall observe in the rest of my journey will be similar to what I have observed up to now.

I take these words to be those of a scientist in command of scientific methods, but knowing their limitations.

Explicitly Stensen rejected ancient as well as contemporary beliefs of inherent qualities like: (1) a formative faculty, *vis plastica*, of rocks; (2) a fictive formative factor in embryology; (3) an imaginative power causing fetal malformations; (4) the Aristotelean principle *antiperistasis*;[254] (5) that some certain animal or vital spirits mediate animal movement; and (6) that all vital processes are governed by the innate heat of the heart. I propose that Stensen's biological and geological investigations were driven by a religious effort to search for traces of inherent qualities. Instead he found the parotid duct, the pennate

---

252. *OPH*, I: 15, p 189.
253. Scherz in his note 74 in *GP*, p 43: "*OPH* vol. 2, p 127 f. Note the methodological doubt, the strong demand for material for observation and the caution before a final decision." Contrary to Scherz, I maintain that Stensen's theories were early "decisions".
254. The Aristotelean idea of a concentration and recollection of one's own force to counteract the attack of an opposing force. Cf. *GP*, p 247, note 6.

structure of muscles, etc. Realizing the limits of human knowledge, he proceeded to a search in pure religion.

In the meantime, by replacing speculations on inherent qualities and final causes with descriptions of efficient causes in time-related dynamic processes applying mathematical analysis, Stensen's writings represent one of the turning points between the scholastic and the scientific approach to biology and geology. From critical analysis, Stensen apprehended, like Galileo, weak points in each of the directions in reasoning: the problem of representation behind inductions,[255] and the problem of reliability behind deductions.[256] Stensen's non-authoritarian position on scientific ideas, his disregard of inherent qualities, his reliance on his own observations and explicit use of a combination of formulation and testing of theories suggest a fitting comparison with the man he admiringly called "Magni Galilei".[257]

Resemblances between Stensen and Popper have been proposed. In the following key texts concerning the status of truth in human knowledge, the two authors use strikingly similar metaphors.

---

255. *OPH*, II: 22, p 98:

> That the same structure can be seen in every muscle not only of the human body, but in any other material. But I still cannot make such an induction. I can, however, assert that neither in a human body nor in any of the rather large number of animals that I have dissected at Florence and other places have I met any example showing the contrary. Since I, therefore, believe that one can find the same motor fiber structure in all the muscles of any animal, until this conclusion is confirmed through further examination, I am proposing it though as an opinion very close to the truth.

See also *GP*, pp 141-43:

> Few take it on themselves to examine all those difficulties without whose resolution the solution of the investigation is left marred and imperfect.

256. *GP*, pp 143-45:

> "In considering the natural world those things which cannot be determined with certainty are not kept separate from those that can be so determined." See also *OPH*, II: 22, p 105: "if it cannot determine the true mode of contraction, it can at least distinguish what is certain from what is uncertain. No one can ignore how much this alone should be valued."

257. "solidissimae Magni Galilei demonstrationes nos docent". *GP*, pp 184-85.

Niels Stensen:

While travellers in unknown territories hasten over rough mountain tracks towards a city on a mountain top, it often happens that they judge the city, at first sight, to be close to them; constantly numerous twists and turnings along the route delay their hope of arrival to the point of weariness, for they see only the nearest peaks; in fact, those things hidden by the said peaks, the heights of the hills, the depths of valleys, or the levels of plains, whatever they may be, far exceed their conjectures, and they, deceiving themselves, estimate the intervening distances from their own desires. Nor is it in anyway different for those who move towards true knowledge through experiments, for as soon as certain tokens of an unknown truth have become clear to them, they believe that the whole matter will be revealed at once."

(*GP*, p 137)

Karl R. Popper:

"The status of truth in the objective sense, as correspondence to the facts, and its role as a regulative principle, may be compared to that of a mountain peak usually wrapped in clouds. A climber may not merely have difficulties in getting there – he may not know when he gets there, because he may be unable to distinguish, in the clouds, between the main summit and a subsidiary peak. Yet this does not affect the objective existence of the summit; and if the climber tells us 'I doubt whether I reached the actual summit', then he does, by implication, recognize the objective existence of the summit. The very idea of error, or of doubt implies the idea of an objective truth which we may fail to reach."

(*Conjectures and refutations*, p 226)

I will not myself have learned the lesson from Stensen if in making such a comparison, I take this as solid evidence for identical conclusions between the authors. Moreover it is possible to find hints of any philosophical claim in earlier writers. Similar positions, however, in Popper and Stensen in regard to the concept of truth, and, as earlier argued, the application of conjectures and refutations in the scientific process, and shared reservations regarding inductive and deductive inferences, lead me to conclude that those[258] who assert Niels Stensen to be a precursor of Karl R. Popper are not far from the truth.

In closing, I want to emphasize the consistency of a scientific concept of truth as correspondence to Nature and the concepts expressed in Stensen's sermon, the *Ornaments*, quoted in section 1.13.

---

258. The late Professor Ole Rafaelsen called Stensen a "Popperian before Popper".

4. Main Theses

I. From Niels Stensen's student notes, the *Chaos*-manuscript, and throughout his scientific publications, to the unfinished scientific writings, the *Addendum*, from his years as a bishop at Hamburg, Stensen's way of arguing reveals that he was a realist who formulated and tested theories through repeated observations in order to approach truth, or Nature, by comparisons. He sought a demonstrative certainty of knowledge by undertaking to find counter proofs in continual matchings. Concepts escaping direct confirmation from observation were formulated as conjectures. Indirect evidence was tested to obtain an opinion close to truth.

II. Building from his studentdays on Galileo, Bacon, Descartes, Gassendi, and other writers, Stensen was a philosopher of science in his own right, not just the brilliant naturalist and anatomist. In practical research he realized the method he summarized in the *Prooemium*: "I will not keep to experiments alone nor bring forward arguments alone, but I will seek such a mixture of both that, by the reckoning of everyone, if not most, at least much will possess a demonstrative certainty."

III. Maar in 1910 concluded that Stensen asked his questions and gave his answers as a scientist of the twentieth century. In words and through practical applications Stensen's method in science resembles the evolutionary approach proposed later in this century by Karl R. Popper.

IV. The transition from scholastic to scientific approach in biology took place gradually in the sixteenth and seventeenth century. From the description of life phenomena within a limited system based on the Scriptures and ancient authors, mainly Aristotle and Galen, the anatomical investigations by Vesalius, the physiological findings by Harvey, and other discoveries extended and transformed the old system. Only gradually, however, was the hold of scholasticism relaxed, resulting in mathematical analysis and the description of life phenomena in open systems as dynamic processes without arbitrary assumptions. A major contribution to this evolutionary process was Stensen's overt and repeated rejection of inherent qualities governing animal movement and biological processes. Similar considerations apply to his contributions in geology and in crystallography.

5. Epilogue

I have wondered why so many of Stensen's sound scientific conclusions were not appreciated for such a long period.

Major Works on Stensen's Achievements in Science

Work numbers are from Vilhelm Maar, *Nicolai Stenonis Opera Philosophica*, 1910. Maar in the introduction commented on most areas of Stensen's research, like Gosch 1873, Scherz 1963, Scherz (ed.) 1968 and 1971, Heida 1986, and Poulsen and Snorrason (eds.) 1986.

Brain research: 18,28	J. Winslow, 1732 G. Scherz, 1968 A. Faller, 1968
Cardiac malformation: 20	E. Warburg, 1942 F. A. Willius, 1948
Cardiology: 10,15	J. Petersen, 1898 F. A. Willius and T. E. Keys, 1941
Cerebrospinal fluid dynamics: 28	T. Kardel and M. Alenius, 1987 F. Gjerris & E. Snorrason, 1992 T. Kardel, 1993
Comparative anatomy: 9,16,17, 19,23,24,25,26	C. C. A. Gosch, 1873 F. J. Cole, 1944
Crystallography: 27	R. de l'Isle, 1783 O. Pedersen, 1991
Female reproductive organs: 16,24,25,26	J. Müller, 1842 E. Lesky, 1968
Fluid equilibrium: 27	
Geology: 23,27,29,30	H. Oldenburg, 1671 E. de Beaumont, 1832 A. Garboe, 1958 G. Scherz, 1969 J. S. Gould, 1981
Glandular research:* 1,2,3,5, 6,7,15	Portal, 1770 R. E. Christensen, 1939 H. Moe, 1986

*Glandular research beyond the mere detection of the parotid excretory duct.

Muscular research: 14,15,22,32	M. Marzollo, 1968 T. Kardel, 1990, 1994
Paleontology: 23	M. J. S. Rudwick, 1972
Philosophy of Science: 2,4,13,18, 22,27,31	C. C. A. Gosch, 1873 A. Georges-Berthier, 1914 A. Faller, 1980
Subterranean meteorology: 29,30	G. Corra and M. Ferrari, 1971

I think that there are, in fact, several reasons: Stensen's humble attitude toward people engendered, however, an obsequiousness that subordinated the significance of scientists to that of scientific ideas; a semi-academic background; a low position in the scientific hierarchy as travelling scientist using no fancy instruments; the publication of major results in four different countries; and not least the fact that Denmark as well as Tuscany, Stensen's second homeland, declined in power. To me, these factors are at least as important as meditations on adverse reactions because of his religious development, since reactions were all the same in London and in Paris, in Amsterdam and in Hanover, in Copenhagen and in Rome.

The avoidance of esoteric methods (p 14–15 and 93) barred him from practicing medicine. At the age of thirty-six he abandoned science, and, like Pascal, he finally realized his ideas in religious renunciation.[259] In contrast to most commentators I do not see the transition as an enigma but consider it as the result of a choice between preferences in a person disengaged from obligations and commissions to do research. Until 1664, Stensen's earliest research had been in response to an academic obligation; later it was in response to commissions from noble benefactors, including his last lecture, the *Prooemium*, which was given as anatomist to King Christian V. No more commissions ensued. To me, the crucial question is not, why did Stensen abandon science? but, why did Stensen not receive any more commissions for research after 1673?

Fellow scientists, I believe, were annoyed with Stensen's criticism and his repeated attacks of deeply rooted assumptions. How else can one explain that hardly any of his scientific theories received consistent support and follow-up? An attitude of extreme criticism shows Stensen as a true disciple of Descartes's famous doctrine. It is expressed throughout his writings with remarks such as: "But most will deny

259. Billeskov Jansen 1986, p 11.

that what they themselves do not know can be either known or is worth knowing."[260] Stensen questioned and changed concepts of both classical and contemporary authors, e.g. Galen, Harvey, Descartes, Bartholin, Wharton, Willis, Croone, Borelli, Kircher, Spinoza, sometimes addressing the author by name, other times not. In spite of qualifications and prolific scientific correspondence with key persons, Stensen was offered no chair at Copenhagen University, was not elected to the scientific academies of Paris[261] or London, and was not used as a scientific advisor by Rome. My point is that the scientific community rejected Stensen, rather than the opposite.

Leiden offered Niels Stensen an opportunity for growth in science and presented him with its diploma as Doctor of Medical Science even though he had left. Florence gave Stensen the recognition, the commissions, the freedom, and the support which brought into a short, yet full blossom one of the brightest talents in science.

---

260. *OPH*, II: 22, p 105. See also *OPH*, I: 15, p 176:
> There are other questions of this kind on which much time and paper have been spent but, finally, when all is considered, they serve to adorn a pleasing discourse but do not contribute at all to discover the truth.

261. In a letter to Stensen dated 31 March, 1667, Jean Chapelain deeply regretted that, because of Stensen's abscence from Paris, Mr Pecquet had been elected a member of the Academy instead of Stensen. *E* 23.

6. List of Abbreviations and References

E=Scherz G. (ed.). *Nicolai Stenonis Epistolae* I-II. Nyt Nordisk Forlag, Copenhagen 1952.

GP=Scherz G. (ed.). *Steno geological papers. Acta hist scient nat med*, vol. 20. Copenhagen 1969.

OPH=Maar V. (ed.). *Nicolai Stenonis Opera Philosophica* I-II. Vilhelm Tryde, Copenhagen 1910.

OTH=Larsen K. Scherz G. (ed.) *Nicolai Stenonis Opera Theologica* I-II, 1944.

Chaos=Stensen N. *A Danish student in his Chaos-manuscript 1659*. Edited by H. D. Schepelern. *Acta hist scient nat med,* vol. 38, Copenhagen 1987.

Bibliography=Jensen M. *Bibliographia Nicolai Stenonis*. Impetus, Mørke Denmark 1986. Michel Jensen's Steno-bibliography is electronically searchable as "STENO" in "COSMOS", the data-base of the Danish National Library for Science and Medicine. An update is expected in 1995.

Biography=Scherz G. *Niels Stensen; eine Biographie* I-II. St. Benno-Verlag, Leipzig 1987.

* * *

Adelmann HB (ed.). *The correspondence of Marcello Malpighi* 1-5. Cornell University Press; Ithaca, New York 1975.

Andersen S. Simon Paulli: *Betænkning over en kongelig ridehest*. [Danish translation]. Dansk Medicinhistorisk Årbog. Copenhagen 1979, pp 9-97.

Bang J. *Afhandling om et Misfoster med Hjernen i en Pose, hengende paa Ryggen; og Formodningerne om Aarsagerne til Misfostre, Modermærker og deslige*. Det kgl Danske Vid Selsk Skr 1801; 1(2).

Bartholin E. *Experiments on birefringent Icelandic crystal* [1669]. Acta hist sci nat med 1991; vol. 40.

Bartholin T. *Bartholinus anatomy; Made from the precepts of his father, and from the observations of all modern anatomists, together with his own*. Culpeper and Cole, London 1668.

—. *Cista medica Hafniensis & Domus anatomica* [1662]. Translated in Danish by N. W Bruun. Ed. by H-O. Loldrup. Dansk Farmaceutforenings Forlag, Copenhagen 1982.

—. *On medical travel* [1674]. Translated by C. D. O'Malley. Univ Kansas Libr Ser 1961; vol. 9.

Bastholm E. *The history of muscle physiology.* Acta hist sci nat med 1950; vol. 7.

de Beaumont, LE. *Fragmens géologique tirés de Stenon, de Kazwini, de Strabon et du Boun-Dehesch.* Ann Sci Nat (Paris) 1832; 25: 337-77.

Biagi MLA, Basile B. *Giovanni Alfonso Borelli.* In Scienziato del seicento. R Ricciardi, Milano 1980.

Bierbaum M, Faller A. *Niels Stensen, Anatome, Geologe und Bischof*; 2. ed. Aschendorff, Münster 1979.

Billeskov Jansen FJ. *Liv og lærdom. Kapitler af dansk videnskabs historie.* Gyldendal, Copenhagen 1983.

—. *Nicolaus Steno's life and fame.* Pp 11-32 in Poulsen & Snorrason (eds.), 1986.

Bonelli ML. *The Accademia del Cimento and Niels Stensen.* Analecta med-hist 1968; 3: 253-60.

Borch O. *Olai Borrichii Itinerarium* I-IV. Edited by H. D. Schepelern. Danish Society of Language and Literature, Copenhagen 1983.

Borelli GA. *On the movement of animals.* English translation of *De motu animalium* by P. Maquet. Springer Verlag, Heidelberg 1989.

Bruun NW. *Zu einem neuen Niels Stensen-Brief.* Analecta Romana, Istituti Danici 1992; 20: 183-4.

Burke JG. *The work and influence of Nicolaus Steno in crystallography.* Acta hist scient nat med 1971; 23: 163-74.

von Bülow K. *Steno's aktualistisch-geologische Arbeitsweise.* Acta hist scient nat med 1971; 23: 149-62.

Casella L, Coturri E (ed.). *Niccolò Stenone Opere Scientifiche* I-II. La nuova Europa, Firenze 1986.

Cole FJ. *A history of comparative anatomy.* Macmillan, London 1944.

Corra G, Ferrari M. *Itinerari di Stenone nelle Prealpi Tridentine e Lombarde.* Acta hist scient nat med 1971; 23: 175-203.

De Graaf R. *Disputatio medica de natura et usu succi pancreatici.* Hackiana, Leiden 1664.

—. *De mulierum organis generatione inservientibus tractatus novus.* Hackiana, Leiden 1672.
—. *Opera Omnia.* Hackiana, Leiden 1677.

De Rosa S. *Un inventario naturalistico di Niccolò Stenone.* Atti della Fondazione G Ronchi, Firenze 1985; 40(3): 349-57.
—. *Niccolò Stenone nella Firenze e nell'Europa del suo tempo.* Leo S. Olschki editore, Firenze 1986.

Descartes R. *Treatise of man.* English translation by T. S. Hall. Harvard University Press, Cambridge, Massachusetts 1972.

Divac I. *Nicolaus Steno: a neuroscientist born too early.* IBRO News 1986; 14: 1/7.

Djørup F. *Bidrag til anatomiens historie i Danmark.* Acta hist scient nat med, vol. 22, 1970.

Drake ET. *Robert Hooke and the foundation of geology: a comparison of Steno and Hooke and the Hooke imprint on the Huttonian theory.* Thesis. Oregon State University 1981. [University Microfilms International]

Eyles VA. *The influence of Nicolaus Steno on the development of geological science in Britain.* Acta hist scient nat med 1958; 15: 167-88.

Faller A. *Niels Stensen und der Cartesianismus.* Acta hist scient nat med 1958; 15: 140-66.
—. *Nicolaus Stenonis, Anatom, Geologe und Bischof.* Universitätsverlag Freiburg (Switzerland), 1978.
—. *Elemente einer Wissenschaftslehre und einer Wissenschaftskritik in den Schriften von Niels Stensen.* Gesnerus 1980; 37: 169-88.
—. *Zur Diskussion um das Stensen Experiment.* Gesnerus 1985; 42: 19-34.
—. *Was erfahren wir über Jan Swammerdam (1637-1685) aus dem Briefwechsel Niels Stensens.* Gesnerus 1986; 43: 241-47.

Ferreira AJ. *Emotional factors in prenatal environment.* J Nerv Ment Dis 1965; 141: 108-18.

Frampton MF. *Aristotle's cardiocentric model of animal locomotion.* J Hist Biol 1991; 24: 291-330.

Frängsmyr T. *Steno and geological time.* Acta hist scient nat med 1971; 23: 204-12.

Fulton JF, Wilson LG. *Selected readings in the history of physiology,* 2nd ed. Charles C. Thomas; Springfield, Ill. 1966.

Gardair J-M. *Le 'Giornale de'Letterati' de Rome.* Acc Tosc Sci Lett "La Colombaria", Firenze 1984; 69: 194-97.

Garboe A. *Nicolaus Steno (Niels Stensen) and Erasmus Bartholinus. Two 17th Century Danish scientists and the foundation of exact geology and crystallography.* Geol Survey Den, 4th ser. 1954; 3: 1-48.

—. *Nicolaus Steno and scientific geology.* Acta hist scient nat med 1958; 15: 99-119.

Georges-Berthier A. *Le mécanisme Cartésien et la physiologie au XVIIe siècle.* Isis 1914-19; 2: 37-89 [first part]. 1920-21; 3: 21-58 [second part].

Gjerris F, Snorrason E. *The history of hydrocephalus.* J Hist Neurosci 1992; 1: 285-312.

Gorham G. *Mind-body dualism and the Harvey-Descartes controversy.* J Hist Ideas 1994; 55: 211-34.

Gosch CCA. *Udsigt over Danmarks zoologiske Litteratur.* Hoffenberg; Copenhagen 1873; 2(1): 149-256.

Gotfredsen E. *Niels Steensen mindehøjtideligheden i Firenze den 24.-25. oktober 1953.* Med Forum 1954; 7: 65-88.

—. *Harvey's lære og dens modtagelse i Danmark.* Novo, Copenhagen 1957.

Gould SJ. *The titular bishop of Titiopolis.* Nat Hist 1981; 90: 20-4. [Also published in Gould SJ. *Hen's teeth and horse's toes.* Norton's paperback 1984: 69-78].

Hall AR, Hall MB. (ed., transl.). *The correspondence of Henry Oldenburg.* University Press, Madison Wisconsin 1965.

Haller A. *Biblioteca anatomica.* Orell, Gessner & Fuessli, Zürich 1774.

Hammond WA. *On the influence of the maternal mind over the offspring during pregnancy and lactation.* Quart J Psychol Med & Med Jurispr 1868; 2: 1-28.

Hansen HM. *A traveller in neuro-anatomy – Stensen 1664-1670.* J Hist Neurosci 1992; 1: 219-26.

— (ed.). *Niels Stensen's korrespondance i dansk oversættelse* I-II. DSL, Copenhagen 1987.

Harvey, W. *An anatomical disputation concerning The Movement of the Heart and Blood in Living Creatures.* English translation by G. Whitteridge. Blackwell, Oxford 1976.

Heida U. *Niels Stensen und seine Fachkollegen.* Grosse scripta, Berlin 1986.

Herrlinger R. *Das Collegium Naturae Curiosum von 1652 und Niels Stensens Beziehungen zu den deutschen Akademikern.* Analecta med-hist 1968; 3: 261-72.

Hibbert C. *The house of Medici: its rise and fall.* Morrow Quill, New York 1980.

Horblit HD. *One hundred books famous in science.* Grolier Club, New York 1964.

Høffding H. *Den nyere filosofis historie.* I-II. P.G. Philipsens Forlag, Copenhagen 1894.

Hölder H. *Stensens Bedeutung für die Begründung der Geologie und Paläontologie.* Acta hist scient nat med 1971; 23: 213-31.

Hsu, K-T. *Nicolaus Steno and his sources: The legacy of the medical and chemical traditions in his early geological writings.* Thesis, University of Oklahoma 1992. [University Microfilms International, no. 9310807].

Il Futuro dell'uomo, anno XIV, nn.1-2: *Niccolò Stenone 1638-1686 Due giornate di studio.* Firenze 1987.

Johnsson, K. *Ignorabimus. A debate on the limits of natural science in the German and Swedish cultural struggle.* [Engl. summary] Lychnos, 1985: 146-48.

Jørgensen AD. *Nils Stensen.* Samfundet til dansk Litteraturs Fremme, Copenhagen 1884. Second annotated edition by G. Scherz, Munksgaard, Copenhagen 1958.

Kardel T. *A specimen of observations upon the muscles: Taken from that noble anatomist Nicholas Steno.* Pp 97-134 in Poulsen & Snorrason (eds.), 1986.

—. *Tale ved kransenedlæggelse ved Niels Stensen's sarkofag i San Lorenzo kirken i Firenze den 23.IX.1986.* Bibl Læger 1986; 178: 338-40.

—. *Niels Stensen's digt om livet og døden.* Medicinsk Forum 1988; 41: 45-48.

—. *Niels Stensen's geometrical theory of muscle contraction (1667): a reappraisal.* J Biomech 1990; 23: 953-65.

—. *Niels Stensen's nye muskelstruktur fra 1667 vinder indpas.* Ugeskr Læger 1990; 153: 331-2.

—. *Steno on hydrocephalus.* Introduction to Niels Stensen's letter 'On a calf with hydrocephalus', with a short biography, followed by anno-

tated English translation and facsimile reprint. J Hist Neurosci 1993; 2(3): 171-202.

—. *Steno on muscles.* Niels Stensen's 'New Structure of the Muscles and Heart' and 'Specimen of Elements of Myology'. Introduction and annotated translation. Trans Amer Phil Soc 1994; 84: Part 1.

Keele KD. *Niels Stensen and the neurophysiology of pain.* Analecta med-hist 1968; 3: 225-35.

Klar F. *Niels Steensen-forskeren GUSTAV SCHERZ.* [With bibliography pp 135-37 by Anne-Liese Thomasen]. Sankt Annæ Kirkes Forlag, Copenhagen 1972.

Koch CH. *Petrus Severinus, Francis Bacon og naturiagttagelsen.* Dansk Medicinhistorisk Årbog. Copenhagen 1979, pp 161-72.

Kongsted O, Rasmussen JN, Ziggelaar A (ed.). *Kirkens fattige tjener.* Katolsk Forlag, Copenhagen 1981.

Kragelund A. *Niels Stensen.* [Annotated second Danish translation of *Prooemium*]. Pp 226-43 in the author's *Den humanistiske renæssance og antikken.* Berlingske Forlag, Copenhagen 1976.

Kuhn T. *The structure of scientific revolutions*, 2nd ed. University Press, Chicago 1970.

Larsen K. *Johann von Rosen: La vie de Nicolas Stenon.* Pp 126-56 in Stenoniana, vol. 1. Ed. by V. Meisen & K. Larsen. Hafnia, Copenhagen 1933.

—, Scherz G (ed.). *Nicolai Stenonis Opera Theologica* I-II. Nyt Nordisk Forlag, Copenhagen 1944.

Lesky E. *Die Entdeckung der Funktion des Säugetierovars durch Nicolaus Stensen.* Analecta med-hist 1968; 3: 235-52.

Lindeboom GA. *Dog and fish.* In Scheurleer THL, Meyjer GHMP. (ed.) Leiden University in the seventeenth century. University of Leiden, Leiden 1975: 278-93.

Lindskog BI. *Några tankar runt vårt medicinska språk.* Dansk Medicinhistorisk Årbog. Copenhagen 1989-90: p 17.

Maar V (ed.). *Nicolai Stenonis Opera Philosophica* I-II. Vilhelm Tryde, Copenhagen 1910.

— (ed.). *Holger Jacobæus' Rejsebog.* Gyldendal, Copenhagen 1910.

— (ed.). *L'autobiographie de J.B. Winslow.* Vilhelm Tryde, Copenhagen and Octave Doin & Fils, Paris 1912.

Malpighi M. *Opera Omnia.* Littlebury, London 1687.

Mazzolini RG. *Schemes and models of the thinking machine (1662-1762)*. Pp 68-83 in Corsi P. The enchanted loom, chapters in the history of neuroscience. Oxford University Press, New York/Oxford, 1991.

Medawar PB. *Induction and intuition in scientific thought*. Mem Am Phil Soc 1969; vol. 75.

Moe H, Bojsen-Møller F. *The fine structure of the lateral nasal gland (Steno's gland) of the rat*. J Ultrastructure Res 1971; 36: 127-48.

—. *When Steno brought new esteem to glands*. Pp 51-96 in Poulsen & Snorrason (eds.), 1986.

—. *Niels Stensen, en billedbiografi*. Rhodos, Copenhagen 1988. English edition: *Nicolaus Steno, an illustrated biography*. Rhodos, Copenhagen 1994.

Mortensen M. *Skønnest af alt, en biografi om Niels Steensen*. Katolsk forlag, Copenhagen 1993.

Møller-Christensen V. *Niels Stensen som kongelig anatom i København*. Dansk Medicinhistorisk Årbog. Copenhagen 1973: 171-97.

Müller J. *Über den glatten Hai des Aristoteles und über die Verschiedenheiten unter den Haifischen und Röchen in der Entwicklung des Eies*. Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin 1840. Berlin 1842, p 187-257.

Negri L, Morello N, Galluzzi P, Bussi AD. *Niccolò Stenone e la scienza in Tosacana alla fine del '600 mostra documentaria ed iconografica*. Catalogo. Biblioteca Medicea Lavrentiana, Firenze 1986.

Neuburger M. *The historical development of experimental brain and spinal cord physiology before Flourens* (1897). Translated by E. Clarke. Johns Hopkins Univ Press, Baltimore 1981.

Noe-Nygaard A. *Nicolaus Steno, Paleontologist, Geologist, Crystallographer*. Pp 167-90 in Poulsen & Snorrason (eds.), 1986.

Nolte J. *Via securitatis et studia pietatis*. In Niels Stensen; Glauben + Wissen; Einheit oder Widerspruch. Publikationen der Katholischen Akademie Hamburg, 1986, vol. 4, pp 77-94.

Nordström J. *Antonio Magliabechi och Nicolaus Steno. Ur Magliabechis brev til Jacob Gronovius*. Lychnos 1962; 20: 1-42. [English summary pp 41-42].

Nygaard JJ. *Niels Stensen*. Forlaget Forum, Copenhagen 1989.

Olden-Jørgensen S. *Thomas Bartholin og Niels Steensen.* Bibl Læg 1992; 184: 277-96.

—. *Niels Steensens sentenser og spiritualitet.* Ælnoths skriftserie no. 2, Gjerrild 1992.

—. *Niels Steensens digte, et par Steensen-petitesser.* AC revue (Helsingør) 1992; 1: 23-27.

—. *Niels Steensens konversion bedømt fra dansk ikke-katolsk hold.* Kirkehistoriske samlinger 1993: 77-93.

Payer L. *Medicine & Culture. Varieties of treatment in the United States, England, West Germany, and France.* Henry Holt, New York 1988.

Pedersen O. *Steno and the origin of crystallography.* Stenoniana, nova series (Cph.) 1991; 1: 113-34.

Petersen J. *Bartholinerne og kredsen om dem.* Copenhagen 1898.

Pontificia Academia Scientiarum. *Blessed Niels Stensen and his memorial plaque in the Pontificial Academy of Sciences.* Academia Civitate Vaticana, Rome 1989.

Popper KR. *Objective knowledge.* Rev. ed. Clarendon Press, Oxford 1979.

—. *Conjectures and refutations.* Rev. ed. Routledge, London 1989.

Portal, M.[Antoine], *Stenon.* Histoire de l'anatomie et de la chirurgie. Vol. 3, pp 159-83. Didot le Jeune, Paris 1770.

Poulsen JE, Snorrason E (eds.). *Nicolaus Steno 1638-1686. A re-consideration by Danish Scientists.* Nordisk Insulinlaboratorium, Gentofte 1986.

Poynter FNL. *Nicolaus Steno and the Royal Society of London.* Analecta med-hist 1968; 3: 273-80.

Pålsson EK. *Niels Stensen, Scientist and Saint.* Oscott series 2. Veritas, Dublin 1988.

Rafaelsen O. *Steno in six languages.* Rhodos, Copenhagen 1986.

Rodolico F. *Niels Stensen, Founder of the Geology of Tuscany.* Acta hist scient nat med 1971; 23: 237-43.

Roos H. *Goethe und Niels Steensen.* Stenoniana catholica (Cph.) 1957; 3: 15-9.

Rothschuh KE. *Descartes, Stensen und der Discours sur l'anatomie du cerveau.* Analecta med-hist 1968; 3: 49-57.

Rudwick MJS. *The meaning of fossils*. MacDonald, London and American Elsevier, New York 1972.

Schepelern HD. *Museum Wormianum*. Wormianum, Århus 1971.

Scherz G. *Im Rufe der Heiligkeit. Zeugnisse zur FAMA SANCTITATIS Niels Stensens*. Herder, Freiburg and Arne Frost-Hansen, Copenhagen 1953.

—. *Vom Wege Niels Stensens*. Acta hist scient nat med 1956; vol. 14.

—. *Nicolaus Steno and his Indice*. Acta hist scient nat med 1958; vol. 15.

—. *Danmarks Stensen-manuskript* [Engl. summary p 222-3]. Fund og Forskning, Royal Library, Copenhagen 1958; 5: 19-33.

—. *Niels Stensen's first dissertation*. J Hist Med allied Sci 1960; 15: 247-64 [+ 12 plates facsimile].

—. *Pionier der Wissenschaften; Niels Stensen in seinen Schriften*. Acta Hist Sci Nat Med 1963; vol. 17.

—. *Neue Stensenbriefe*. Centaurus 1967; 3: 167-81.

—. *Da Stensen var i Paris* [Engl. summary p 152]. Fund og Forskning, Royal Library, Copenhagen 1969; 16: 43-52.

— (ed.). *Nicolai Stenonis Epistolae* I-II. Nyt Nordisk Forlag, Copenhagen 1952.

— (ed.). *The historical aspects of brain research in the 17th century*. Analecta med-hist 1968; vol. 3.

— (ed.). *Steno geological papers*. Acta Hist Scient Nat Med 1969; vol. 20.

— (ed.). *Dissertations of Steno as geologist*. Acta Hist Scient Nat Med 1971; vol. 23.

—, Beck P. *Niels Steensen (Nicolaus Steno) (1638-1686)*. Royal Danish Ministry of Foreign Affairs, Copenhagen 1988. [Available from the publisher in Danish, English, German, French, and Italian].

Schiller J, Théodoridès J. *Sténon et les millieux scientifiques parisiens*. Analecta med-hist 1968; 3: 155-70.

Schlichting TH. *Das Tagebuch von Niels Stensen*. Centaurus 1953-54; 3: 305-10.

Schmalor H-J. *Book-review of Michael Jensen: Bibliographia Nicolai Stenonis*. Mitteilungsblatt der Arbeitsgemeinschaft Katholisch-Theologischer Biblioteheken (AKThB) 1987; 34: 146-7.

Snorrason E. *The studies of Nicolaus Steno 1659 in Copenhagen libraries*. Analecta med-hist 1968; 3: 69-93.

—. *L'anatomiste J.-B. Winslow 1669-1760*. Novo, Copenhagen 1969.

—. *Nicolaus Steno, the illustrative expositor.* Pp 191-209 in Poulsen & Snorrason (eds.), 1986.

Steno N. *Foreløbig meddelelse til en afhandling om faste legemer der findes naturlig indlejrede i faste legemer* (1669). [Translated by A. Krogh & V. Maar]. Gyldendal, Copenhagen 1902.

—. *The earliest geological treatise (1667).* Translated by Axel Garboe. MacMillan, London 1958.

—. *Lecture on the anatomy of the brain.* [1669 French edition in facsimile with translations in English and German. Introduction by G. Scherz and anatomical annotations by A. Faller]. Nyt Nordisk Forlag Arnold Busck, Copenhagen 1965.

Stensen N. *Hirtenpflicht.* [Edited and translated by G Scherz]. Aschendorff, Münster 1962.

Swammerdam J. *Tractatus physico-anatomico-medico de respiratione usuque pulmonum (1667).* Opusc select Neerl Art Med 1927; 6: 106-7.

—. *Miraculum Naturæ sive uteri muliebris fabrica.* Leiden 1672.

—. *Biblia Naturae.* [Edited by H. Boerhaave] German translation. Opusc select Neerl Art Med 1907; 1: 83-135.

Veraja F (ed.). *Beatificationis et Canonizationis ... Nicolai Stenonis ... Positio.* Vatican, Rome 1974.

Vesling J. *Syntagma anatomicum.* Schouten, Utrecht 1696.

Vugs JG. *Leven en Werk van Niels Stensen.* Universitaire pers Leiden, Leiden 1968.

Wagner PH. *Steno and Ray; two geologists and men of faith.* Pp 153-66 in Poulsen & Snorrason (eds.), 1986.

Wharton T. *Adenographia sive glandularum totius corporis descriptio.* J. G., London 1656.

Wiberg J. *Galen og den Galenske Lægevidenskab og Lægekunst.* Thesis. Andelsbogtrykkeriet, Odense 1910.

Wieh H. *Niels Stensen. Sein Leben in Dokumenten und Bildern.* Echter, Würtzburg 1988.

Willius FA. *An unusually early description of the so-called tetralogy of Fallot.* Proc Staff Meet Mayo Clin 1948; 23: 316-20.

—, Keys TE (ed.). *Cardiac Classics.* Mosby, St. Louis 1941; 99-104.

debet prius extrahi verum extractum : Melius tamen est ex substantia ipsa extrahere, qvam ex succo inspissato. Scio aliqvos dicturos, hoc antea scivimus, qvibus respondeo; cur ergò non facitis. Cur memores moneam, hæc causa est, qvod aliqvando audiverim, hoc vel illud ex una officina fortius prodire qvam ex altera, cujus differentiæ diversitas ex præparatione varia dependet, ut mirum non sit si seqvatur diversus affectus. De spiritibus Vegetabilium in genere aliàs dicam.

CXXIV.

Proœmium demonstrationum Anatomicarum in Theatro Hafniensi anni 1673.

D. Nicolai Stenonis.

QVod vestro me conspectui sistam, spectatores omnis ordinis dignissimi, autoris in opus suum liberalitas est, Regis in subditum favor, mea de benevola omnium vestrorum attentione exspectatio.

Placuit Deo multa mihi non qværenti, imo reluctanti in Anatomicis detegere, aliis longe dignissimis ante me denegata. Placuit Regi a multis jam annis clausum theatrum patrium hodie aperire observationibus aliorum simul & meis publice demonstrandis, Placeat vobis non ad ora manusq; monstrantis, sed ad monstranda Dei in operibus suis miracula attendere.

Qui Musæum ingrediuntur rariora ibi undiq; suspensa & disposita, indice virga seu radio custodis, lustraturi, non offenduntur, si qvando radius vilioris formæ fuerit, licet alias etiam ipse radius affabre elaboratus spectantium in se oculos converterit. Radius seu virga in manu Dei Anatomicus est, rariora corporis velut Musæi alicujus conqvisitissimi indi-

7. Niels Stensen

Preface to Anatomical Demonstrations in the Copenhagen Theater in the Year 1673[262]

Translated by
Sister M. Emmanuel Collins, O.S.F., Ph.D.
and Paul Maquet, M.D., Doct. h.c. (Paris)

That I stand in your presence, most worthy spectators of every rank, results from the generosity of the Creator towards his work, the favour of the King toward his subject, and my own expectation of the benevolent attention of all of you.

It has pleased God to disclose to me, although to one not seeking but rather reluctant, many things long denied before me to other anatomists far more worthy than myself. It has pleased the King to open today the anatomical theatre of his fathers,[263] closed for many years, to show publicly the observations of others as well as mine. May it please you to pay attention not to the words and hands of the demonstrator, but to the revelation of the wonders of God in his works.[264]

The visitors of a museum who want to see there the curiosities hung and set about everywhere, indicated by the pointer or the rod of the custodian, do not feel offended if perhaps the pointer is rudely fashioned whereas an elaborately fashioned pointer will draw the attention of the spectators to itself. The anatomist is a pointer or a rod in the hand of God, pointing out the curios-

---

262. Nicolaus Stenonis: *Prooemium demonstrationum anatomicarum in theatro Hafniensi Anni 1673. Acta medica & philosophica Hafniensia*, 1673, printed 1675, II, pp 359-66. German and Danish translations, see Bibliography #1244-52. This is the first English translation, based on *Nicolai Stenonis Opera philosophica* (ed. V. Maar) II, pp 249-56, Copenhagen: Vilhelm Tryde 1910.

263. Copenhagen's *Domus Anatomica* was founded in 1642 during the rule of King Frederik III by one of Stensen's teachers, Professor Simon Paulli (1603-1680). The house was described by Thomas Bartholin (1616-1680) in his *Domus anatomica Hafniensis brevissime descripta*, Copenhagen 1662. Danish translation: Thomas Bartholin, *Cista Medica Hafniensis*, by Niels W. Bruun and Hans-Otto Loldrup, pp 185-240, Copenhagen, Dansk Farmaceutforening 1982. The building no longer exists.

dicans, qvi aliqvando & ipſe ſpectari meretur ob dictionis ſectionisq; elegantiam, quæ laus præceptoribus meis, prædeceſſoribus hoc in loco celeberrimis debetur: aliqvando verò, id quod in me agnoſco lingvæ vitiis manuum lapſus adjugens offenderet potius, qvàm delectaret, niſi rerum artificium ſpectatorum in ſe attentionem totam abriperet.

Quod ſi verò & ipſum cadaver prima fronte qvibusdam parum venuſtum aliis autem ob luridam mortis imaginem etiam horrendum videatur: illos omnes obnixè rogatos volo, ne nimis faciles ſint in habendo fidem ſenſibus. æq; enim nos fallunt ſenſus quando in Silenis Alcibiadis vilia omnia & ridicula judicant ex facie ridicula & vili, atq; cum ſimiam in purpura magni æſtimant ob externi coloris ſplendorem. Solus mundus plura & majora promittit qvàm præſtat, Natura plura & majora præſtat qvàm promittit, uterq; ſano loqvendi modo fallit, dum utrobiq; quæ latent diverſa ſunt ab iis qvæ apparent. Gratus tamen ille error eſt, qvi, qvæ ut inferiora, imo ingrata vel ſprevit, vel timuit, mox ſumma & gratiſſima cum magno ſenſu voluptatis agnoſcit. Adamantes, ut primum vel e ſaxis excuſſi, vel ad montium pedes e limo eruti oculis exhibentur, nil non aſperum & ſordidum præ ſe ferunt, at verò cum artificis ſolertia corticem deformem inde removit, ſplendore ſuo & pretio inventorem, præ lætitia extra ſe rapiunt, de reliqvis lapidibus pretioſis ipſoq; auro eandem nos veritatem fodinarum inſpectio docet; ut taceam, uniones non niſi fœtidiſſimis putreſcentium oſtreorum e carnibus eluendos, qvæ omnia exempla demonſtrant, qvod ſenſibus ingratum velum gratiſſima iisdem ſenſibus corpora ſæpius occultet.

Sed nec ſolus incultus habitus venuſtates elegantiſſimas abſcondit, qvandoqvidem etiam ipſa illa naturæ opera, qvorum,

ities of the body like the guide of an exquisite museum. The <360>
anatomist himself sometimes deserves to be noticed because of the elegance of his diction and dissection. Such praise belongs to my teachers, my most famous predecessors in this place. Sometimes, however, the slip of his tongue and the clumsiness of his hands – this I acknowledge for myself – would rather offend than delight, if skillful craft did not rivet all the attention of the spectators by itself.

But if at first glance the cadaver itself seems little attractive to some and even looks horrifying to others as a livid image of death, I will ask them all with insistence not to trust too easily their senses. The senses indeed deceive us as well when, in the Silenes of *Alcibiades,*[265] they consider everything as contemptible and ridiculous, because the outward appearance is ridiculous and contemptible, as when they esteem highly a monkey dressed in purple because of the brilliance of the external colour. The world only promises more and greater things than it offers; Nature offers more and greater things than it promises. Strictly speaking, both are deceitful, since with both, what lies hidden is different from what appears. It is, however, a pleasant error when one recognizes as the best and the most delightful what he had at first despised or feared as inferior or even most unpleasant. Diamonds, either struck from the rocks or retrieved from the mire at the foot of the mountains, at first sight present nothing but crudeness and filth; but, when a skillful craftsman has removed the ugly shell, they elate the discoverer by their brilliance and value. Inspection of the mines teaches us the same truth about the other precious gems and even about gold, not to speak of pearls which can only be washed off from the stinking flesh of rotting oysters. All these examples show that a veil unpleasant to the senses very often conceals objects most pleasant to the senses.

But it is not only a crude garment which conceals the most

---

264. Commenting on his translation, the second Danish translation of the *Prooemium,* the Latinist A. Kragelund (1894-1985) indicated as typical for Stensen, sentences in triplets. Cf. A. Kragelund, *Den humanistiske renæssance og antikken.* Copenhagen, Berlingske Forlag 1976, pp 226-43.

265. The Silenes, kin of Silenus, the foster father of Bacchus, god of sensuality, are satyrs, as Silenus was, the images of brute sensuality, half human – half beast. According to Kragelund a reference to Plato's *Symposium,* 215a. Stensen used the same figure in his first printed work, OPH I, p 17.

rum externa ſpecies in ſui nos amorem abripit, interna rimantibus talem decorem aperiunt, ut foris patens elegantia, latentis intus pulchritudinis non niſi leve indicium eſſe manifeſtò deprehendatur. Qui formoſiſſimo anni tempore prarum e loginqvo intuetur, ex colorum pulcherrimorum mixtura magnum ſuavitatis ſenſum oculis percipit: inde verò ubi in ipſo prato ad ſingularum plantarum folia & flores accuratius inſpiciendos ſeſe incurvaverit, illa figurarũ & colorum varietas atq; elegantia ſeſe exſerit, ut exclamare cogatur, e longinqvo ea pulchra apparent, ſed in vicinia longe ſunt pulchriora: qvod ſi verò ulteri⁹ perrexerit vel in una tantum planta ſcrutaturus, particularum eam conſtituentium in vena tantum planta ſcrutaturus, particularum eam conſtituentium intrinſecam conformationem, & fluidorum omnia ibi peragentium meatus motusq; ſeriemq; mutationum dum tranſitus fit e ſemine in plantam perfectam novum ſemen parturientem; licet de his omnibus vix pauciſſima, nec niſi per nebulam diſcat, tantum tamen inde videt, ut agnoſcat voluptatem ex cognitis perceptam, nullam eſſe ad illam qvam perciperet, ſi integra potuerit cognoſcere, qvæ latent. In ſuo de Senectute Cicero agnovit, qvantes vires habeant ad animum voluptate permulcendum, vel ſola illa, qvæ ruri circa ſegetes conſpiciuntur; licet mirabilium, qvæ ibi fiunt, non niſi leviſſima qvædam velut argumenta obſervaverit. Quanta formæ humanæ in animos humanum vis ſit & efficacia, fatebuntur omnes, qui unquam meminere ſe ullius formæ veneres animo non ſatis contra illecebras præparato intuitos fuiſſe: id omne nihilominus qvod in externa facie tam validum eſt, eſt floridi prati e longinqvo proſpectus, prætereaq; nihil: ut enim de prato non niſi exigua pars qvorundam florum videtur, ſic in homine non niſi ſuperficies externa, & qvidem ſecundum minimam ſui portionem

elegant beauties. Those works of Nature, the outward appearance of which impels us to love them, disclose also such grace to the ones who examine their inside that the visible external elegance obviously gives only a slight idea of the hidden inner beauty. Who looks at a meadow from a distance in the loveliest time of the year, experiences a most pleasant visual sensation from the mingling of delightful colours. But when then he stoops over the meadow itself to look more closely at the leaves and flowers of the individual plants, such a variety and beauty of shapes and colours unveil themselves that he is compelled to exclaim: from a distance they appear beautiful, but nearby they are far more beautiful! But if, indeed, he proceeds even further and examines in one single plant the inner structure of the different constituent parts, the goings and displacements of the fluids which perform all (vital) actions, in the transition from seed to the mature plant producing new seed, even if he becomes acquainted very little with all that as if it were through a mist, yet he sees enough to acknowledge that the pleasure experienced from what is known is nothing compared to that he would experience if he could know all that lies hidden. <361>

In his book *On old age*,[266] *Cicero* recognizes how much power even those things alone which are seen in the fields of the countryside have to delight the mind, although he observed only some of the least wonders which happen there as proofs of his assertion. How great the power and the influence of the human shape are on the minds of men, all will acknowledge, who recall having looked closely at the loveliness of a figure, with a mind not sufficiently prepared against enticements. And all this external appearance which has such a powerful effect is, however, like the view from a distance of a meadow in blossom, nothing else. For, as in the field, only a small part of some flowers is seen, similarly in man nothing but the external appearance, and

266. *Cato Maior, seu de Senectute*, §§51-54.

conſpicitur. Quid enim ex toto homine patet obvio alii præter vultum & manus? & in his ipſis qvantulacunq; ſuperficiei portio eſt, qvæ noſtros ſenſus ferit? ſanè, qvi novit differentiam inter ſuperficiem corporum realem & apparentem, vel qvi ſaltem microſcopium cuti admovet, fatebitur, nos de cute humana non niſi rudiores qvosdam illius apices & velut ex agri remoti ſegete ſummas ſpicarum ariſtas videre. Quod ſi verò illa manus, cujus externus nitor & proportio ſæpius intuentis animum totum occupat, criſtalli inſtar pellucens ſimul exhiberet tendinum ibi latentium & calorem margaritis æmulum, & ingenioſiſſima qvæq; ſuperans artificium, qvis non longe majorem inde voluptatem ſpectantium mentibus polliceretur. In ipſis autem partibus, cute nempe & tendine, ſi ulterius pergere liceret, & fibrarum texturas artificioſiſſimas, meatuumq; plexus & labyrintos ingenioſiſſimos intueri, de qui bus omnem ſenſum fugientibus vix pauciſſima, nec fere niſi per conjecturam aſſeqvimur, qvis amplius in ſolius externæ ſuperficiei perceptione ſenſibili hæreret, & ex illius perceptionis ſvavitate, vel moleſtia, de reliqvo judicaret? imo quis non rejecto omni ſenſuum errore, ingemiſcaret, pulchra qvæ ſine diſſectione ſenſibus patent; pulchriora, quæ diſſectio ex abditis penetralibus protrahit; longè autem pulcherrima, quæ ſenſus fugientia, ope tamen ſenſibilium per rationem agnoſcuntur.

Ut avertant animos a noxiis amoribus Ethici, in objecto amoto reprehendenda omnia inveſtigant, Anatomicus autem talium amorum remedia rogatus non ad culpanda ſe dimitteret, ſed ad amoris argumenta nobiliora animum amantem elevaret, modò non omnino ineptum ſupra ſenſus ſeſe tantillum attollendi: quod ſi autem ſuavitatum illicitarum deſiderium ſcepticum eum finxerit potius, qvàm verè effecerit (nec n. qvenquam aliter ſcepticum eſſe reor, niſi qva-

even very little of it, is seen. What else of the entire man does indeed one see than his face and hands? And of these how very small a part of their surface affects our senses? Frankly, he who knows the difference between the real and the apparent surface of the bodies or who at least applies the microscope on the skin, will admit we see nothing of the human skin except its rougher tips, just as of the vegetation on a distant field we see only the highest tips of the ears. But actually if this hand, the pretty and well proportioned external aspect of which so often draws the entire attention of the observer, at the same time, transparent like a crystal, revealed also the colour of the tendons hidden there, rivalling pearls, and their artefact which surpasses every ingenuity, who would thence not promise the minds of the spectators a far greater pleasure? Yet if one is allowed to proceed into these same parts, the skin and the tendons, and to look closely at the most skilfully wrought textures of the fibres, the complexity of their course and the intricacy of their labyrinths of which we grasp very little and this only by conjecture since they escape every sense, who would cling any longer to the sensible perception of the external appearances alone and, from the attractiveness or the unpleasantness of that perception, judge the rest? Yes indeed, after having rejected all the errors of the senses, who would not repeat: beautiful is what appears to the senses without dissection; more beautiful what dissection draws forth from the hidden inside; yet by far the most beautiful is what, escaping the senses, is revealed by reasoning helped by what the senses perceive. <362>

In order to turn souls away from harmful desires, moralists trace out all which is blameworthy in the object of love. The anatomist, however, asked for remedies for such desires, would not stoop to reproaches, but would raise the loving soul to nobler reasons of love, provided this soul is not completely unable to raise itself a little above the senses. If, however, longing for illicit pleasures has made him looksceptic rather than having

qvatenus rerum illicitarum amor vitii excusationem a dubitationis obstinatione mutuatur) etiam hujus de sensibus qverelas facile tollemus. Accusat sensus, quod non exhibeant res, ut in se sunt, sed omnia nobis vel falsa vel saltem incerta relinqvant. Quæ vera esset qverela, si sensibus rerum judicium esset committendum, at non ita nobiscum comparatum est, & cum sensibus nostris; non est sensuum exhibere res ut sunt, vel de iis judicare, sed illas rerum conditiones rationi transmittere examinandas, quæ sufficiunt ad notitiam rerum, fini hominis convenientem acqvirendam.

Habemus rationem sensibilium judicem, cujus ope cum per sensibilia certus detur ascensus ad insensibilia, absit hominem exuendo infra bestias nos collocaremus; quin potius seqventem veritatem certissimam freqventi meditatione ruminando ex ignorantia ad scientiam, ex imperfectione ad perfectionem ascendentes de vera hominis dignitate dignas homine cogitationes in nobis excitaremus. *Si minima portio superficiei humanæ adeo venusta est, & tanto opere afficit intuentem, qvas venustates videremus, qvas perciperemus voluptates, si integrum corporis artificium, si animam, cui tam numerosa simul & artificiosa obediunt instrumenta, si horum omnium a causa, qvæ nos ignoramus, omnia sciente dependentiam intueremur?* Pulchra sunt qvæ videntur, pulchriora qvæ sciuntur, longè pulcherrima qvæ ignorantur.

Ne itaq; in sensibus hæreamus amplius, sed mentis oculis per oculos corporis tanqvam per fenestram artificiosissimi palatii prospiciamus amœnissimum hoc pratum, in qvo, qvot partes, tot flores, qvot particulæ tot miracula occurrunt. Nec est, qvod sordes mihi & foëtores objiciant, unde tota humorum proportio adeo in qvibusdam turbatur, ut ipsos etiam invitos extra theatrum vel detineant vel expellant. Debilitas hæc corporis est, cui mens in arcta illa unione cede-

made him truly sceptic, (and I do not think that anybody is a sceptic except insofar as his love for illicit things finds an excuse for the vice in the obstinacy of doubt), even then we easily toss aside his complaints about the senses. He blames the senses for not displaying things as they are by themselves, but leaving us with either a false or, at best, an uncertain picture of everything. That complaint would indeed be legitimate if the judgment of things were committed to the senses. But this is not the case with ourselves and with our senses. It is not the function of the senses to display things as they are or to judge them, but to transmit to the reason those conditions of the things to be examined, which are sufficient for acquiring a knowledge of things appropriate to man's purpose. <363>

We have reason as a judge of the perceptible, thanks to which a reliable approach to the imperceptible is given us. Far be it for us no longer to be men and put ourselves below the beasts. Pursuing the most certain truth by pondering in frequent meditation, let us rather rise from ignorance to knowledge, from imperfection to perfection, and raise in ourselves thoughts worthy of man about his own true dignity. *If the smallest part of the human outer aspect is so beautiful and so greatly affects the observer, what beauties would we see, what pleasure would we experience, if we contemplated the entire structure of the body, if we gazed upon the soul which so many and so ingeniously constructed instruments obey, if we considered the dependence of all this on the cause who knows all that we do not know.* Beautiful is what we see, more beautiful what we know, but by far the most beautiful is what we do not know.

So let us not dwell further on the senses, but with the mind's eyes, through the bodily eyes, as through a window of a very artistic palace, let us look out over this most delightful meadow in which there are as many flowers as there are parts and as many wonders as there are particles. Do not bring up with me the filth and stench of the cadavers which disturb so much the balance of the humours in some people that, even against their will, they keep them away or drive them from the anatomical theatre. This is the weakness of the body to which the mind, in

re interdum tenetur, licet vel eodem illo tempore non colores illi fordeant, sed ignorantia, non corpora fœteant sed crimina. Nec enim aliter meretur divinæ auræ, non pars, sed exemplar appellari, nisi cum illis solis offenditur, qvibus offenditur ipsa, unde profluxit, divina aura, illis solis delectatur, qvibus eadem aura divina suam nobis prudentiam, potentiam & bonitatem tacita qvidem, sed omnem eloquentiam superante facundia, eloqvitur.

Et hic verus Anatomes finis est, ut per corporis stupendum artificium in animæ dignitatem, & consequenter per utriusq; miracula in autoris notitiam & amorem spectatores subleventur. Cum enim objectum ejus sit corpus animale, & in specie humanum, qvatenus in illas partes resolvendum qvæ sensibus exponi possunt, non poterit tanta tamq; evidens pulchritudo, qvin sui admiratione excitet desiderium sciendi, qvæ sensus fugiunt, unde ratio ex singularum partium intuitu, & diversarum comparatione mutua elevetur ad auctorem tantorum miraculorum investigandum; de qvo notitias eò plures acqvirit, qvò minori cum præsumptione & pleniori exstirpatione præjudiciorum vastam illam experientiarum sylvam perlustrat: si enim nemo sanæ mentis statuam, picturam, horologium, automata qvaliacunq; pulchre elaborata intuetur, quin illico se moveri sentiat ad autorem illorum amandum, & magni æstimandum? Qui posset humani corporis fabrica omnem humanam artem infinitis parasangis præcedens oculis attentis considerari, absq; perceptione motus vehementis ad autorem ejus venerandum & amandum? Quin imo hæc mirabilis divinæ providentiæ circa creaturas facultate reflectendi præditas, administratio est, ut primò secundum singulas perceptionum vias mille voluptatibus illam perfundat, inde desiderium excitet inqvirendi veram earundem voluptatum causam, tandem per

qvæ-

its close union with it, is sometimes forced to yield. Yet, at the same time, those colours are not filthy, but ignorance is; bodies do not stink, but crimes do. The mind indeed deserves to be called, not a part of, but an image of the divine breath only if the mind feels offended by that alone which offends the divine breath from which it derives, and it rejoices in that alone by which the divine breath speaks to us of prudence, power, and goodness in a discourse, silent indeed, but surpassing all eloquence. <364>

And this is the true goal of Anatomy: Through the stunning work of art of the body to lift the spectators up to the dignity of the soul and, consequently, through the miracles of both (body and soul) to the knowledge and love of the Creator.[267] Since indeed its object is the animal body, and particularly the human body in so far as this body must be dissected into parts which are accessible to the senses, such great and such obvious beauty cannot but arouse admiration and hence the wish to know what escapes the senses. This stimulates reason, from the consideration of the different parts and from the comparison of the single individual parts, to search after the author of such wonders. Reason acquires the more knowledge of this art, the less the presumption and the more complete the rooting out of prejudices with which it surveys that vast forest of experiences. If, indeed, no sensible man can look at a statue, a picture, a clock, machines and whatever well contrived machinery without immediately feeling driven to love the maker of such objects and to appreciate him, how should one gaze with attentive eyes at the structure of the human body which infinitely surpasses all human art, without feeling a forceful impulse to venerate and love its creator? The admirable rule of the divine providence for the creatures endowed with the ability to think is such that, at first, it rather overwhelms this ability with thousand delights through the different ways of perception, then it arouses the wish to seek out the true cause of these pleasures and finally,

267. Augustine, *Confessions,* IV 10, X 6.

qvæsita inveniendam, qvò possint agnito in donis donatore, motum amoris omnem a donis in donatorem transferre. Frustra itaq; sunt & infra rei dignitatem cum Anatome agunt, qui solis morbis præcavendis aut curandis eam famulam faciunt; habet qvidem illa suum ibi usum, non tamen qvantum credimus, cum status præternaturalis agnitio non possit ultra cognitionem status naturalis sese extendere; hæc autem cum etiamnum sit admodum limitata necilla fines suos multum promovere poterit. Verè autem vera Anatome, qva omnibus spectatoribus accommodatur, methodus est, qva Deus nos primo in corporis animalis, inde in sui notitiam mediante manu Anatomici perducit. Nec enim sibi debet arrogare Anatomicus, quæ vel invenit, vel demonstrat; ipse Dei opus circa opus Dei, Deo non modo spectante, sed & operante Dei opus agit, nec sibi absq; Deo quicquam verè tribuere poterit, præter defectus & errores, qvocirca & ego omnes vos rogatos volo, si qvid videritis dignum vestra exspectatione, divinam bonitatem mecum laudetis, errores verò omnes tum lingvæ tum manuum meæ vel impatientiæ adscribatis, vel me ipsum latenti superbiæ, cui plura fortè aut majora saltem alia desideranti præter Dei voluntatem, etiam illud ipsum jure denegaretur, qvod alias facilè obtinuissem. Deo itaq; Duce aggressurus præsentis corporis demonstrationem anatomicam, eò dirigam omnia, ut qvæ hactenus circa corpus certis vel experimentis vel rationibus innotuere vestris oculis & mentibus exponantur. Stultorum ea persvasio est, sufficere ut Anatomicus partes præparatas oculis explicet, à spectatoribus cætera propria lectione vel meditatione domi posse absolvi. Id quod ubens admitterem, si de Anatome nihil exstaret a majoribus scriptum ut verum, qvod nostra sæcula falsum agnovere, aut

through discovering what was sought for, to find a way to recognize the giver in his gifts and to transfer all impulse to love from the gifts to the giver. Those who make it merely the servant for the prevention and healing of disease are in error, therefore, and treat Anatomy beneath its dignity. It does have a certain use there but not as much as we think since the recognition of an extraordinary state cannot extend beyond the knowledge of its natural state. Since the latter is yet quite limited, the former cannot advance its limits much further. <365>

True Anatomy, however, which fits all observers, is a method by which God leads us first to the knowledge of the animal body, and thence of God Himself by way of the hand of the anatomist. For the anatomist should not arrogate to himself either his discoveries or his demonstrations. He is just a creature of God, engaged in the work of God, who not only watches on but also operates His own work. He cannot rightly attribute to himself apart from God anything except his own deficiencies and errors. Therefore, I want to ask all of you to praise with me the divine Goodness if you see something worth your expectation but to ascribe all errors of my tongue and hands to my impatience or a pride hidden for myself, which perhaps wishes more or greater or at least other things beyond the will of God and to which then is deservedly denied even that which I should have obtained easily otherwise. And so, with God as my guide I shall proceed to the anatomical demonstration of the present body. I will do everything to display to your eyes and to your minds what we know hitherto about the body through reliable researches or reasoning. The belief that it is sufficient for the anatomist to explain the parts prepared for the eyes, that the rest can be completed by the spectators through reading or thinking at home, is silly. I would gladly admit that assumption if there was nothing written on Anatomy by our predecessors as being true which we in our time have recognized as erroneous, or if the mind engaged in the search for truth proceeded free from all prejudices. Now this is far from being so and, since nothing is more difficult to give up than prejudice, even what is carefully published today is not so deprived of errors that

ſi nullis mens præjudiciis occupata veritati examinandæ cum libertate accederet. Jam verò longè aliter res ſe habet & cum nihil difficilius deponatur, qvàm præjudicia, ne qvidem hodierna ſcripta, etiam qvando qvis maximè attendit, adeo pura eduntur, qvin præconceptæ opiniones ſua ibi reliqverint veſtigia; e qvibus ſi & ego me eximerem, ſuperbiæ inſolentiſſimæ notam mererer. Ut verò pro viribus, & a mea errandi facilitate præſens veritatis ſtudium defendam, & commiſſos ab aliis errores evitem, nec in ſolis hærebo experimentis, nec ſolas rationes afferam, ſed talem utriusq; mixturam qværam, ut, ſi non pleraq;, ſallem multa omnium calculo certitudinem demonſtrativam ſint habitura. Eo fine illa ſola ex generali corporum ſcientia adducam, qvæ omnibus etiam diſſidentibus inter ſe philoſophis communia ſunt, ut in qvodam ſcripto alias me explicui, & corporis partes non pro locorum varietate, ſed ſecundum ſubſtantiæ atq; functionum convenientiam proponam, ut ſimul & brevitati conſulatur & evidentiæ. In erroribus aliorum refutandis parcior ero, memor dicti a viro non minus pio qvàm ſapiente. *Cognitio veritatis*, ait, *omnia falſa, ſi modò proferantur, etiam qvæ prius in audita erant & dijudicare & ſubvertere idonea eſt.*

α & ω

preconceived opinions do not leave their traces, and if I exempted myself from such prejudices, I should deserve the stamp of the most insolent arrogance. Indeed to defend this pursuit of the truth to the best of my ability, conscious of the easy risk of error, and to avoid the mistakes committed by others, I will not keep to experiments alone nor bring forward arguments alone, but I will seek such a mixture of both that, by the reckoning of everyone, if not most, at least much will possess a demonstrative certainty. To this end from the general science of bodies I shall put forward only that which is common to all philosophers, even to the most opposed among them as I have explained elsewhere in one of my writings.[268] I shall present the parts of the body not according to their different positions, but according to their substance and their functions, so as to be mindful of both brevity and clarity. I will be rather moderate in the refutation of the errors of others, remembering the words of a man as pious as he was wise: <366>

The knowledge of the truth, he says, *is sufficient*
to discern and overturn all errors,
even those formerly unheard
of, if they are only
brought to light.

268. *De solido intra solidum, OPH* II, p 188.

8. Niels Stensen's Public Dissection no. XVI of a Female Cadaver in Copenhagen's Anatomical Theatre 1673

described by Holger Jakobsen (Jacobæus)

Translated by
Sister M. Emmanuel Collins, O.S.F., Ph.D.
Paul Maquet, M.D., Doct. h.c.
and day, 29 January, by
August Ziggelaar, S.J., D.Phil.

Introduction

Holger Jakobsen, or Jacobæus (1650-1701), was born in Aarhus, Denmark. He studied medicine and theology in Copenhagen. An educational excursion to Leiden in 1671 was interrupted by unrest and war. The following two years he studied with Niels Stensen in Copenhagen as described in Jacobæus's manuscript *Exercitatio anatomica (OPH 36)*. In 1674 he became professor of history and geography at Copenhagen University, yet allowed to go for the grand educational tour until 1679, for a period visiting Stensen in Italy. He became later professor of medicine and rector of the university for several periods and a judge to the Supreme Court in 1691.

Jacobæus's report on Stensen's anatomical demonstrations on a woman's corpse, 29 January-8 February 1673 is preserved by the Royal Library, Copenhagen, NKS 309 aa 4°. Vilhelm Maar edited it in *Nicolai Stenonis Opera Philosophica*, vol. II, pp 300-307. The editor mentions, on p 345, that Jacobæus also copied the published text of Stensen's famous preface though with a few omissions. Maar does not edit this copy. Here it is edited from the manuscript at the Royal Library, Copenhagen and compared with the preface published in the present volume.

Text from the preface which is in the published edition but not in Jacobæus's account, is set here within square brackets [ ]. Indeed, the manuscript and the published version are verbally and literally so close that there must be some more direct relation between them than the sheer fact that Jacobæus took notes of what he heard Niels Stensen say. There are no illustrations in this manuscript. Matching illustrations have been added from papers published shortly after the event.

29 Jan.

Public Dissection no. XVI
OF A FEMALE CADAVER
in the Anatomical Theatre

<fol. 145v>

29 January, 2 o'Clock in the Afternoon <fol. 146r>

Why[1]

First, the prosector held a speech about Anatomy and its dignity, and about God's admirable works. From this speech I made this small selection.

[HJ omits Stensen's acknowledgment of the favour of the Creator, of the King and of the audience, his mention of his discoveries and of the re-opening of the anatomical theatre.]

The visitors of a museum who want to see there the curiosities hung and set about everywhere, indicated by a pointer or rod [of the custodian], do not feel offended if perhaps the pointer is rudely fashioned. [Otherwise the pointer draws the attention.] A pointer or a rod in the hand of God is the anatomist, pointing out the curiosities of the body like the guide of an exquisite museum. [More on the person of the anatomist.]

If [at first glance] the cadaver is little attractive and even looks horrifying [to others] as a livid image of death, I will ask the spectators [with insistence] not to trust too easily their senses. The senses indeed deceive us as well when, in the Silenes of Alcibiades, they consider everything as contemptible and ridiculous, because the outward appearance is ridiculous and contemptible, as when they esteem highly a monkey dressed in purple because of the brilliance of the external color.

[Unlike the world, nature yields greater things than it promises.] Diamonds, either just struck from the rocks or retrieved from the mire at the foot of the mountains, at first sight, present nothing but crudeness and filth; but they elate the discoverer by their brilliance and value. Inspection of mines teaches us the same truth about the other precious gems and about gold, not to speak of pearls which can only be washed off from the stinking flesh of rotting oysters. All these examples show that a veil unpleasant to the senses very often conceals objects most pleasant to the senses.

[Often outward lovely appearance is only a sign of inner beauty.]

Who looks at a meadow from a distance in the loveliest time of the year, experiences a most pleasant visual sensation from the mingling of delightful colors. But then when he stoops over the meadow itself

---

1. The only word in the margin. Its reading is uncertain.

to look more closely at the leaves and flowers of individual plants, such a variety and beauty of shapes and colors unveil themselves that he is compelled to exclaim: from a distance they appear beautiful, but nearby they are far more beautiful! But if he proceeds even further and examines in one single plant the inner structure of the different constituent parts and the goings and displacements of the fluids which perform all actions in the transition from seed to the mature plant producing new seed, even if he becomes acquainted very little with all that as if it were through mist, yet he sees enough to acknowledge that the pleasure experienced from what is known compared to that he would experience if he could know all that lies hidden.

[Quotation from Cicero. The danger of enticements.] As in the field only a small part of some flowers is seen, similarly in man nothing but the external appearance, and even very little of it, is seen. What else of the entire man does indeed one see than his face and hands? And of these how very small a part of their surface affects our senses? Frankly, he who knows the difference between the real and the apparent surface of bodies or who at least applies a microscope on the skin, will admit that we see nothing of the human skin except its rougher tips, just as of the vegetation of a distant field we see only see the highest tips of the ears. But if this hand, the pretty and well proportioned external aspect of which so often draws the entire attention of the observer, at the same time, transparent like a crystal, revealed also the color of the tendons hidden there,and rivalling pearls, the most skilfully wrought textures of the fibres, the complexity of their course and the intricacy of their labyrinths who would thence not promise the minds of the spectators a [far] greater pleasure?

[Beautiful is what appears, more beautiful what dissection shows; by far the most beautiful what is acknowledged by reasoning. Illicit pleasures. Reason is the judge of the perceptible. Man's dignity. Beautiful the outer aspect; what if we contemplated the entire structure of the body, if we considered the cause who knows all that we do not know.] Beautiful is what we see; more beautiful what we know, by far the most beautiful is what we do not know.

[Praise of the human mind]

This is the true goal of Anatomy: Through the stunning work of art of the body to lift the spectators up to the dignity of the soul, and, consequently, through both miracles to knowledge and love of the Creator.

[HJ omits all the rest of the preface.]

After having finished the discourse he brought forth the structure of the nerves of the entire body, separated artificially and displayed on a table, a gift from Henrik Fuiren, and he explained it shortly for the board spectators.

January 30 in the Afternoon

He [Stensen] separated the cuticle with the skin and all the teguments, which others name differently. He ascertained only three layers: the skin, the subcutaneous fat, and groups of motor fibres.

He said that there would be opportunity to deal with the skin among parts which are found around narrowings of the blood vessel.

That consideration of fat belongs more to the chemist than to the anatomist. What some bring forth about blood vessels which they think to be peculiar to the fat, is not yet that certain.

It is certain that in many parts fat is collected under the membrane around the vessels and the collection is sometimes drained out. Stensen said he himself did not know how the particles leave the blood and return back into it, possibly either through vessels of their own kind or excretory, such as in the kidneys, and in other parts, or indiscriminately through pores.

The groups of motor fibres constitute the third common tegument. We indeed see that cavities are formed from muscles, bones, and membranes, or from fleshy and tendinous fibres: motor fibres and that some muscles for some part of them provide for the cavity of the abdomen, for another part of them for the cavity of the breast.

He showed the viscera of the breast and the abdomen in their natural site.

[He showed] the muscles of the abdomen descending obliquely or external, ascending obliquely or internal, transverse and straight.

He said that the peritoneum is nothing but a continuation of the tendons of the muscles of the abdomen and diaphragm, as is the pleura, which on both sides by its cavity envelops the lungs and on the medial side of their cavities these form the mediastinum.

He explained the method of conceiving the site of the parts outside of the membranes: if one imagined each of the leaves of an Indian figtree, tightly surrounded by a cloth, to continue down to the ground and there to be turned back upwards again to clothe all the leaves together in a single common envelope.

Concerning the peritoneum and the pleura, it must be noticed that there are different terms such as the mesenterium, the mesareum, the ligament by which the liver is suspended [the falciform ligament], the bat-wings [the broad ligament] of the uterus, their duplications and recesses; all designate various parts of the same membrane in so far as they extend differently from the contained parts; thus in the breast, the mediastinum is part of the pleura.

He showed the thymus in the breast.

The pericardium with its heart and water.

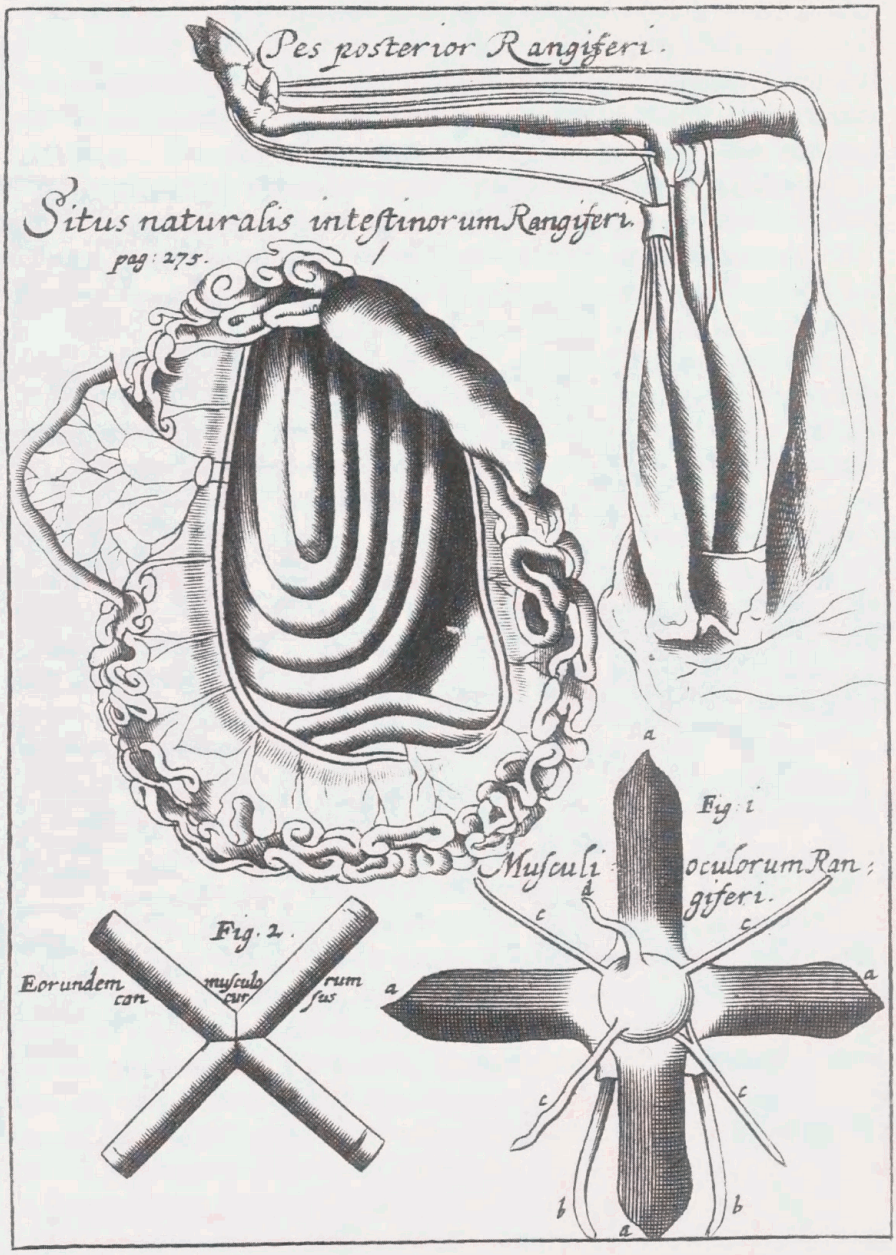


Fig. 16. Intestinal tract of reindeer. *Acta Med & Phil Hafn* 1673, vol. 1, p 275a. The drawing is slightly different in style from that of Stensen's other illustrations and resembles closely the style of Holger Jacobæus in *Exercitia academica*.

In man the apex of the heart almost always inclines somewhat to the left, but the basis in a central position shows the auricles at the sides.

When several parts join together, to one of them is ascribed what belongs to another. 2. The defects of the fluids are very often attributed to the solids. Since the spleen, the intestine leaving the narrowings of the mesentery, the stomach, the colon, and the kidney are found close to each other, all pains in the left side are mostly ascribed to the spleen, although the spleen itself is often absolutely healthy. Thus, in the cadaver of an elderly, always believed to be splenetic, Stensen saw that the spleen was perfect but the left kidney was full of gravel. The very famous *Sylvius* confirmed that he had discovered a healthy spleen in many who had been considered as suffering from a splenic condition, but that the intestine adjacent to the spleen was almost always swollen. Colics are also confused with pain caused by a stone. The second mistake is that, while the uterus in hysterics, and in hypochondriacs the viscera situated in the upper abdomen, are being blamed, more often the defect is in the blood itself, in a humour receding from the blood, but not in the uterus or in the other viscera. What to say about the fact that symptoms of hysterics ascribed to the uterus for the most part are also common to males. Sure, the connection alone of the uterus with neighboring organs suffices to show that symptoms in the upper abdomen, in the diaphragm and in the oesophagus must be traced back elsewhere than from the uterus.

January 31

He arranged the viscera drawn from another human subject on a large board in the order in which they follow each other.

The digestive tract is narrower in some places, wider in others. Dilatation appears mainly in the mouth, the stomach and the colon. The narrower canal between the mouth and the stomach is called the oesophagus. The dilatation starting from the oesophagus is the stomach, the beginning of which is the cardiac orifice, its end the pyloric orifice. Between the stomach and the colon the canal from the pylorus to the orifice of the bile duct is the duodenum. The long canal from there is called the jejunum and then, at the end, the ileum. The caecum is the appendix connected to the beginning of the colon. The last part following the colon is the rectum.

To show the different conformations of the digestive tract in different animals, he compared the alimentary systems of a reindeer recently dissected, of a little fox, of a monkey, of a dormouse, of a hen, and of a rayfish.

In the reindeer [see Fig. 16] the intertwining spirals of the thin and the thick intestines presented an elegant picture.

The caecum [is] double in birds. In ostriches, the tract has a delicate membranous spiral surging on the inner surface.

In the ray the caecum is single and as small as seen in some birds.

In the marten and the bear there is none; in the monkey it seems to be a stretching of the thick outside the thin.

In man, although somewhat longer, yet it is almost always empty.

In the hare and the rabbit it is rather long and interiorly provided with a spiral like in ostriches and filled with excrements, but never up to the top. On the contrary, around the end a visible parenchymatous substance appears from which a large portion of humour may be secreted from the blood into the caecum.

In the reindeer and the doe, it is altogether long and ample, without spiral, full of liquid excrements.

In the Islandic little fox and the dormouse it is fairly ample in proportion to the animal, twisted and containing excrements.

The variety of the colon is also noteworthy.

In the marten and in bears no difference has been observed from the other intestines.

In man, while in some places it is constricted in length by motor fibres extended like bands, it is divided into different small chambers.

In dormice, the colon, arranged in an elegant manner, has inside several equal angles following each other along the length of the intestine where the spreading out of the legs which constitutes the angles faces the rectum.

Various things can be moved about the digestive tract.

Men become more quickly inebriated by small draughts than by full beakers; indeed abundant quantities swallowed at once flow down by their own weight; whatever does not touch the surface of the oesophagus or the stomach cannot transfuse its particles into the blood. But taken in small portions they transmit into the blood whatever spirit they contain by licking the surface of almost all parts of the mouth and of the oesophagus before descending to the stomach.

The digestive tract does not keep the same width from the mouth to the anus. It is found to be wider in some places and narrower in others.

The contents of the digestive tract fall into 2 categories, one, of the intakes, and the other of the excretions from the blood. If the fluids and solids taken in, after having been broken up and mixed outside the body were left to themselves, they would react on themselves and, in freeing particles, they would produce heat and bubbles sometimes simultaneously, whereas in the digestive tract they are added fluids secreted from the blood. These fluids have been prepared earlier from

bodies of the same kind by way of the blood, and secreted through the sieves of glands and of the liver. This has two effects: their loosening proceeds more easily and only those which fit that individual are separated.

The entire duct from the mouth to the anus must be recognized as the place from which the distribution of the chyle begins, since spirituous liquors taken in by the mouth restore the strength of a tired man with pleasure almost instantaneously, and practitioners do not deny the efficacy of nourishing clysters nor the ability of mercurials in starting salivation.

Two things concur to the appetite, either a bitterness exciting the membranes, or pain from the constriction of the membranes because of emptiness. Perhaps true hunger occurs when both causes concur. It is certain that, when we abstain from food, the resolving fluid becomes more bitter the more frequent it carries out its circuit. If no new food arrives, the stomach is constricted after its contents have been expelled. All those would convince themselves that bitterness alone is not sufficient, who at certain hours after a meal vomited very bitter matter, without feeling hungry, unless perhaps one could answer that at the same time the inside of the stomach could have been coated by a crust of phlegm not allowing the canceling of a bitterness of that sort.

We turn away from excrements, not because they are excreted by our body, for many animals live on excrements of other animals, and man likewise prepares not only the most pleasing odors but also food for himself from the excrements of other animals. He even mixes his food with his own excretions, such as saliva not yet spilled from the mouth, and he lives on his own excrements within the womb.

February 1

He next went to the dissection of the brain, since it quickly grows yellow and does not bear waiting.

Concerning the fibrous and white matter it is agreed that the impression of perceptible objects is transmitted to the mind through the extension of this matter into the nerves and that the decision of the will is transmitted from the mind to the motor fibres through the same fibrous matter. Both are proved by the most reliable experiments. When, after the nerve has been cut, or ligated, or otherwise impeded in whatever way, both feeling stops and the obedience due to the mind is lacking in all the parts toward which the same nerve sends branches, although the motor fibres are not denied movement.

All that is said about the animal spirits being distributed through the nerves is questionable. It is certain that, after intake of liquors like

spirit of wine, a certain restoration of strength is felt. However, one does not know whether absorption of the liquor itself within the nerves occurs, or whether there is a larger amount of common fluid, or whether there is swifter movement, etc.

About the small particles at the base of the pineal gland, nothing else can be brought forward than what must be said about the small particles to be found almost everywhere in the rest of the body and is explained by the example of the building up of tartar on the teeth. There, indeed, the saliva clinging to the teeth gradually loses its more fluid parts, while thicker parts condense with time and harden. Or, to put forward a more common example, salt condenses in proportion to the evaporation of water from salt water. Tartar condenses at the bottom of a jar in proportion to the evaporation of spirit through the pores of the jar. Silver dust previously dispersed in *aqua fortis* condenses in proportion to the *aqua fortis* raised through an alembic. Similarly, both in the gallbladder, in the kidneys, in the small glands either of the tongue or of the rest of the body, and in the skin of gouty people, small stones condense in proportion to the evaporation of a thinner fluid.

Whatever the Ancients, whatever the Moderns imagine about the brain itself is by no means in agreement with the truth. After the error about the material part has been acknowledged, they will grow accustomed to philosophize more cautiously about the worthier part.

The brain can be divided into four parts, on both sides one lateral part, one posterior part, which is the cerebellum, the base from which the nerves and the spinal cord spring; 4 kinds of tubercles; the upper and the lower small gland [=the pineal body and the pituitary gland].

February 3

After the tunics of the eyes had been separated, he pointed out the aqueous, the vitreous, and the crystalline humors.

[He showed] the two muscles of the nictitating membrane, one, cone-shaped, the tendon of which is inserted in the membrane, the other, square, one side of which is in the outer membrane of the eye, the other having a perforated tendon.

One cannot deny a cause in the light moving it over almost infinite distances and carrying out its operation almost instantaneously, nor a cause of perception in the brain, nor a dependence of both moving and perceiving together, with the entire series of intermediate particles, either fluid, or solid, on the universal cause, which we call God.

What the perceiving cause or the mind can perceive by way of the

narrow opening of the pupil surpasses all wonder: the vast space and hemisphere of the skies, distant bodies such as the heavenly bodies, countless objects such as the stars.

The nose separating the eyes brings about that we see many things at the same time with one eye that we do not see with the other, even that which we see with both eyes, we do not see with both eyes at the same place. This is proved by a simple experiment with a glass window. One place for the union of double vision is not needed within the brain, but one place in the brain corresponds to any part of the eye which perceives an object, and the mind perceives the single objects at their own places and without any confusion.

February 4

He examined the ear in which there are 3 small bones, the incus, the stapes and the malleus.

It is certain that movement is diffused gradually from the center of percussion in every direction, a fact which he explains through the movement of vibration visible on the surface of water around a stone thrown into it. This is proved by experiments, that of the strings which produce a sound at the stroke of similar similarly tensed strings, and that of glass which at first vibrates totally to the human voice and finally shatters.

Two cavities communicating with the outer air, one outside through the external ear, the other inside through the nose; other cavities [are] more hidden, which are called the cochlea and the labyrinth. They seem rather to be different recesses of one single cavity. Three ossicles, nerves and muscles.

The labyrinth in birds and fishes is different. In the other animals indeed, it comprises circles carved in solid bone; in birds the circles are bony surrounded by cancellous bone; in fishes the circles are cartilaginous contained within cartilage of similar shape.

February 5

He showed the small glands of the eye, the passages from the eyes into the nose, from the nose into the mouth, the salivary glands, the tegument of the palate, of the lips, etc.

For a long time the glands were considered an obscure part of the body, until *Wirsung*, discovering a special duct in the pancreas, opened the way both to find the vessels and to recognize the function of the other glands. The glands are no longer to be considered either as a useless part of the body or as a part destined only for superfluous

humours, but as a sieve separating from the blood a fluid necessary for the preservation of the individual. Hence through the whole digestive tract, there are such sieves, either very small and diversely scattered, or joined together into remarkable bodies.

The lymph nodes returning into the blood the humour recovered through vessels named after the famous *Thomas Bartholin*, have the same conformation as the kidneys, as for the concavity of the place from where the excretory vessels leave and as for the convexity of the opposite part.

Regarding the liquid which has to be returned to the blood through the vessels of these small glands, it is certain that within a few hours after eating, the vessels between the intestines and the left subclavian vein are full of a milky liquor, in the other vessels the liquor is watery.

The salivary glands, two at either side, the lower was described by *Wharton*, the excretory duct of which ends beneath the root of the tongue, and the upper gland was discovered by *Steno*.

The entire interior tegument, the tegument of the cheeks and lips is replete with minute glands which Prosector calls labial.

There are many minute glands in the oesophagus above the crop in birds.

February 6

He dealt with the reproductive organs, the uterine tubes, the seminal organs, the uterus, etc.

In women, narrowings of the blood vessels are found in the seminal organs which must be called properly ovaries, as well as in the body and in the cervix of the uterus.

Women have an ovary, or vesicles (the liquor of which condenses into albumen when the vesicles are cooked) enclosed in membranes with narrowings of blood vessels and a substance of its own kind, from which the vesicles are automatically separated at the suitable time and extracted uninjured by means of skill.

The oviduct is a canal open towards the ovary and outward. In some it is single, in others double. Where it is double, in some it is divided about the middle.

Man's seed does not remain in the oviduct, but either the whole or the main part of it perhaps penetrates within the blood and [the nervous system?]. This also results from experiments of *Harvey* who found nothing in the uterus although he opened several fallow deer to this end.

The maternal blood never penetrates the membranes of the egg. This is demonstrated at first in the early days by the egg visible in the

oviduct where the egg is found completely free, then about the time of birth when the placenta or cotyledons are divided into two parts, one adhering to the egg, the other to the uterus and no drop of blood is to be seen in any division.

The foetus is fed by and grows from a serous humour transmitted through the placenta from the mother's blood into the blood of the foetus and excreted in the outer surface of the foetus which transmits its parts within the amnion in a continuous circulation from the outer surface to the inner and vice versa, until finally the more bitter returns render the foetus restless by their stimulation, from which movement the uterus is stimulated to expel.

This very deed considered in itself, most worthy of all deeds of preservation, is also accompanied by the very great pleasure put there by the Creator in reward for those who carry it out properly. The harshest symptoms are set forth as a punishment for those who abuse it so that they finally take refuge in mercurials. To them Nature proclaims that if pleasure is not enough for arising love, pain is able to arise fear.

February 7

He dealt with the lymph nodes and blood circulation.

The total picture of the blood vessel is to be examined carefully according to the method at use among mathematicians. To this end let us imagine a canal with neither a beginning nor an end, i.e. returning back into itself, which we shall divide into 4 parts [see Fig. 17]. In the first part [E, Pulmonary circulation], let us imagine the same canal split into several minute canals so that all the content must move from the ample space of the whole canal through the aforesaid narrowings equal in cross-section to the first whole channel. Let us leave the second [G-H, left side of heart] and the fourth part [B, right side of heart] intact and undivided. Let us divide the third [systematic circulation] part into 3 canals, two of which, however, must be provided in one place, the third [splancnic circulation] in two places, with narrowings similar to the narrowings of the first part. In the second and in the fourth part let us set double sluices in any part of the two so that, after the contents have been transmitted through them, the return to where they came from will not be open. Thus we have completed the true internal picture of all of the blood vessel. The narrowings of the first part correspond to the lungs [E]; the sluices through the second and fourth parts are in the heart with its valves. All this can be better recognized in the following figure [Fig. 17]:

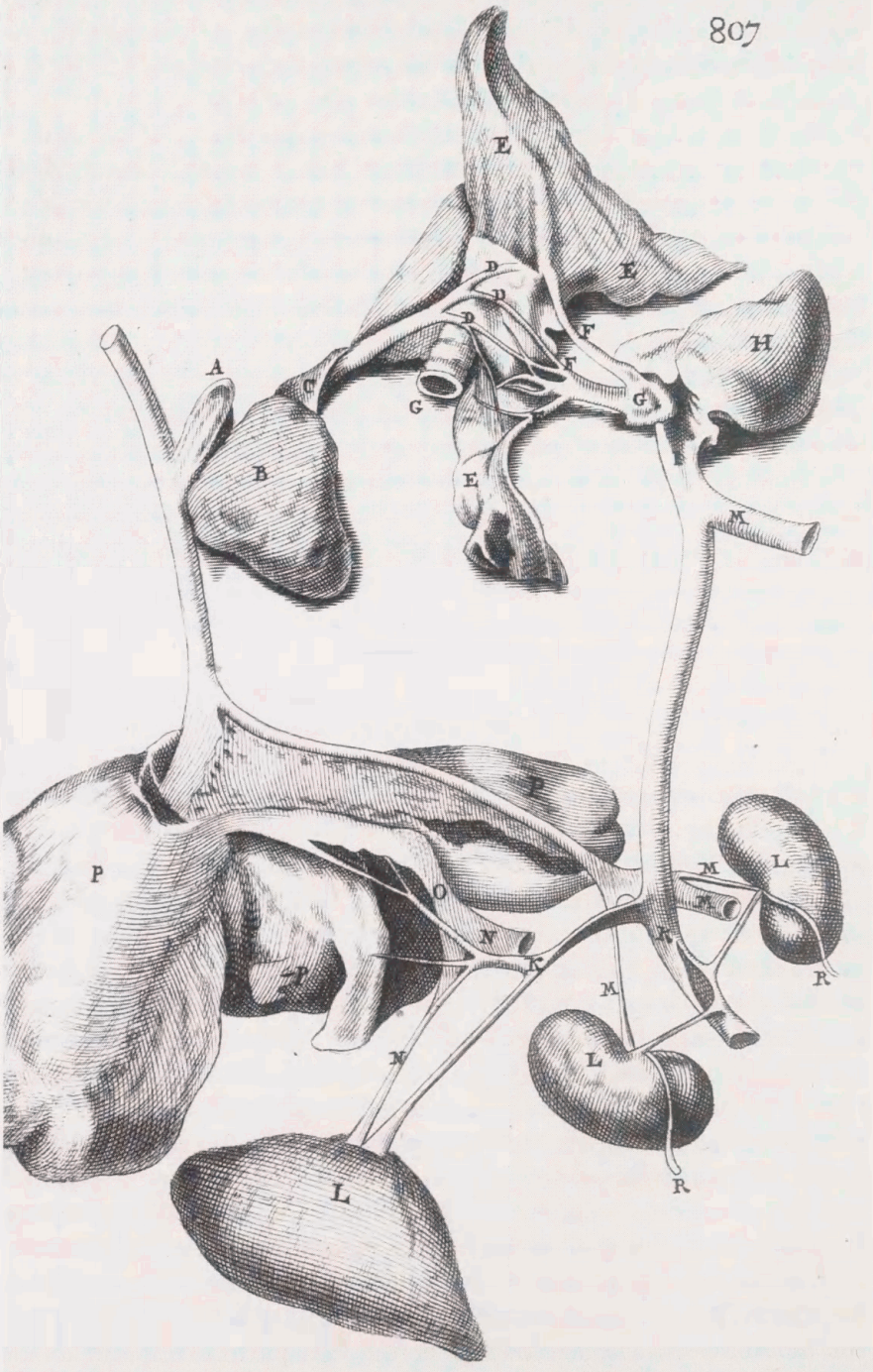


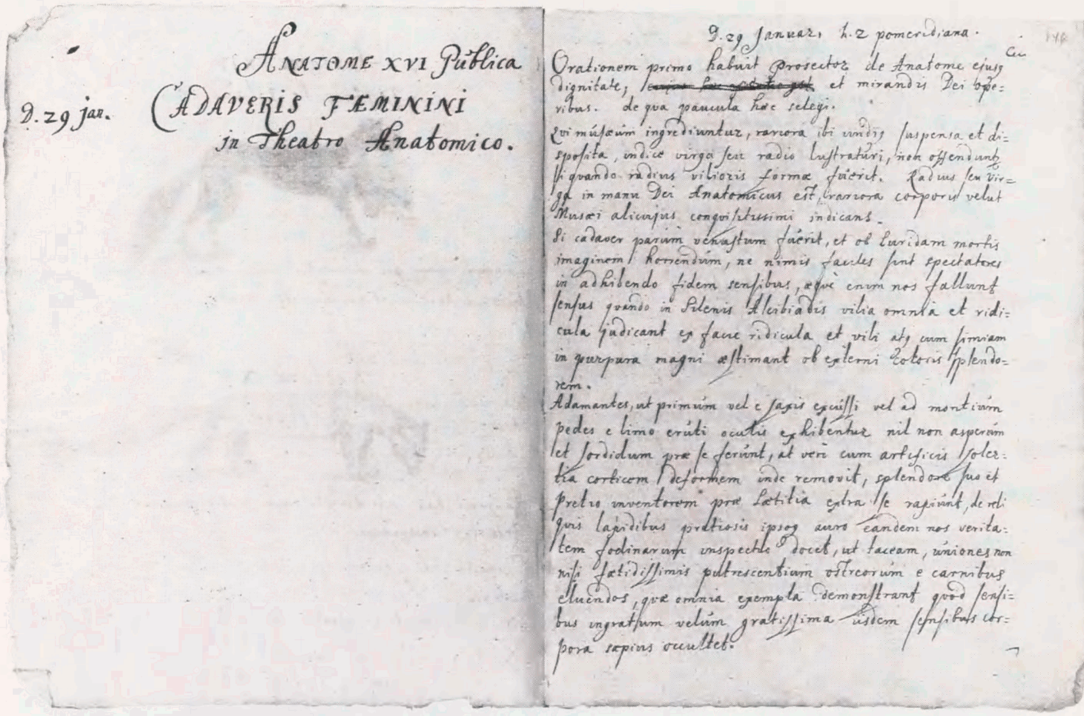
Fig. 17. Stensen's diagram of the circulation of the blood in Thomas Bartholin, *Anatome quartum renovata*, Leiden 1674, p 7.

February 8

He pointed out the muscles. He called the heart a muscle the fibres of which have their extremities in the base and their middle in the apex or about the apex.

The apex of the heart is thin so that there is nothing except inner and outer membranes concurring and touching each other.

The fibres of the tongue are threefold: straight, perpendicular, transverse.



Anatome XVI Publica
D. 29 jan. Cadaveris Fæminini
in Theatro Anatomico.

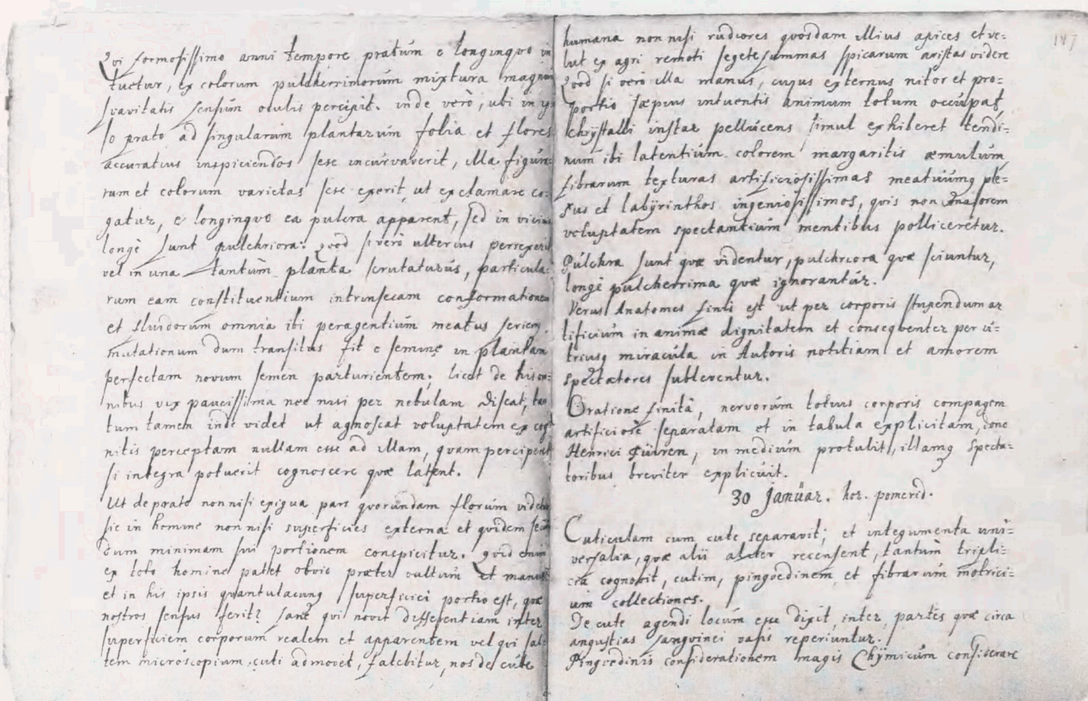
D. 29 Januar. h. 2 pomeridiana. 146

Orationem primo habuit Prosector de Anatome ejus dignitate, [illegible] et mirandis Dei operibus. de qua pauxula hæc selegi.

Qui musæum ingrediuntur, rariora ibi undis suspensa et disposita, indice virga seu radio lustraturi, non offendunt si quando radius vilioris formæ fuerit. Radius seu Virga in manu Dei Anatomicus est, rariora corporis velut Musæi alicujus congestissimi indicans.

Si cadaver parum venustum fuerit, et ob lividam mortis imaginem horrendum, ne nimis faciles sint spectatores in adhibendo fidem sensibus, qui enim nos fallunt sensus quando in Silenis Alcibiadis vilia omnia et ridicula judicant ex facie ridicula et vili atq cum simiam in purpura magni æstimant ob externi coloris splendorem.

Adamantes, ut primum vel e saxis excissi vel ad montium pedes e limo eruti oculis exhibentur nil non asperum et sordidum præ se ferunt, at veri cum artificis solertia corticem deformem inde removit, splendore suo et pretio inventorem præ lætitia extra se rapiunt, de reliquis lapidibus pretiosis ipsoq auro eandem nos veritatem fodinarum inspectio docet, ut taceam, uniones non nisi fœtidissimis putrescentium ostreorum e carnibus eluendos, quæ omnia exempla demonstrant quod sensibus ingratum velum gratissima iisdem sensibus corpora sæpius occultet.



Qui formosissimo anni tempore pratum e longinquo intuetur, ex colorum pulcherrimorum mixtura magnam suavitatis sensum oculis percipit. inde vero, uti in ipso prato ad singularum plantarum folia et flores accuratius inspiciendos sese incurvaverit, illa figurarum et colorum varietas sese exerit, ut exclamare cogatur, e longinquo ea pulcra apparent, sed in vicinia longe sunt pulchriora: quod si vero ulterius perrexerit vel in una tantum planta scrutaturus, particularum eam constituentium intrinsecam conformationem et fluidorum omnia ibi peragentium meatus seriemq mutationum dum transitus fit e semine in plantam perfectam novum semen parturientem, licet de his omnibus vix paucissima nec nisi per nebulam discat, tantum tamen inde videt ut agnoscat voluptatem ex conspectu perceptam nullam esse ad illam, quam perciperet si integra potuerit cognoscere quæ latent.

Ut de prato nonnisi exigua pars quorundam florum videtur sic in homine nonnisi superficies externa et quidem ejusdem minimam sui portionem conspicitur. quid enim ex toto homine patet obvio præter vultum et manus et in his ipsis quantulacunq superficiei portio est, quæ nostros sensus ferit? sane qui novit differentiam inter superficiem corporum realem et apparentem vel qui saltem microscopium cuti admovet, fallitur, nos de cute

147

humana non nisi rudiores quosdam illius apices et velut ex agri remoti segete summas spicarum aristas videre quod si vero illa manus, cujus externus nitor et proportio sæpius intuentis animum totum occupat crystalli instar pellucens simul exhiberet tendinum ibi latentium colorem margaritis æmulum fibrarum texturas artificiosissimas meatuumq plexus et labyrinthos ingeniosissimos, quis non majorem voluptatem spectantium mentibus polliceretur.

Pulchra sunt quæ videntur, pulchriora quæ sciuntur, longe pulcherrima quæ ignorantur.

Verus Anatomes finis est ut per corporis stupendum artificium in animæ dignitatem et consequenter per utrumq miracula in Autoris notitiam et amorem spectatores sublevarentur.

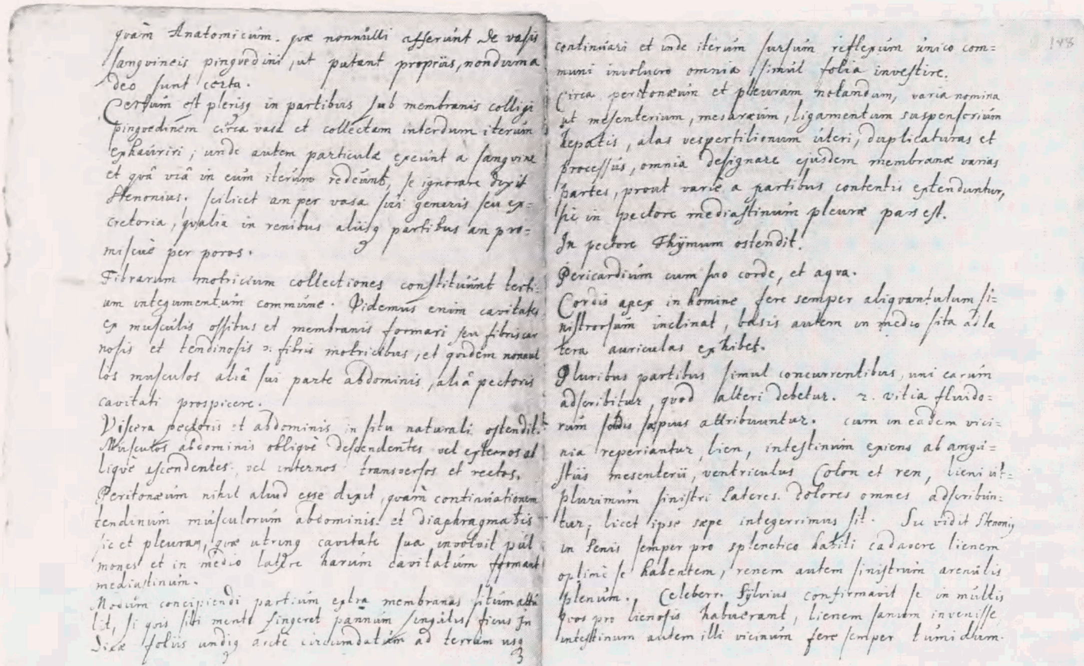
Oratione finita, nervorum totius corporis compagem artificiose separatam et in tabula explicitam, dono Henrici Fuiren, in medium protulit, illamq spectatoribus breviter explicuit.

30 Januar. hor. pomerid.

Cuticulam cum cute separavit; et integumenta universalia, quæ alii aliter recensent, tantum triplicia cognovit, cutim, pinguedinem, et fibrarum motricium collectiones.

De cute agendi locum esse dixit inter partes quæ circa angustias sanguinei vasi reperiuntur.

Pinguedinis considerationem magis Chymicum considerare



quam Anatomicum. quæ nonnulli afferunt de vasis sanguineis pinguedinis, ut putant propriis, nondum adeo sunt certa.

Certum est pleriss in partibus sub membranis colligi pinguedinem circa vasa et collectam interdum iterum exhauriri; unde autem particulæ exeunt a sanguine et quâ viâ in eum iterum redeunt, se ignorare dixit Stenonius. scilicet an per vasa sui generis seu excretoria, qualia in renibus aliisq partibus an promiscuè per poros.

Fibrarum motricium collectiones constituunt tertium integumentum commune. Videmus enim cavitates ex musculis ossibus et membranis formari seu fibris carnosis et tendinosis i. fibris motricibus; et quidem nonnullos musculos aliâ sui parte abdominis, aliâ pectoris cavitati prospicere.

Viscera pectoris et abdominis in situ naturali ostendit. Musculos abdominis obliquè descendentes vel externos obliquè ascendentes vel internos transversos et rectos.

Peritonæum nihil aliud esse dixit, quam continuationem tendinum musculorum abdominis et diaphragmatis sic et pleuram, quæ utring cavitate sua involvit pulmones et in medio latere harum cavitatum formant mediastinum.

Modum concipiendi partium extra membranas situm abbilt, si quis sibi mente fingeret pannum singulis fiens in [illegible] foliis undiq arcte circumdatum ad terram usq

continuari et inde iterum sursum reflexum unico communi involucro omnia simul folia investire. 148

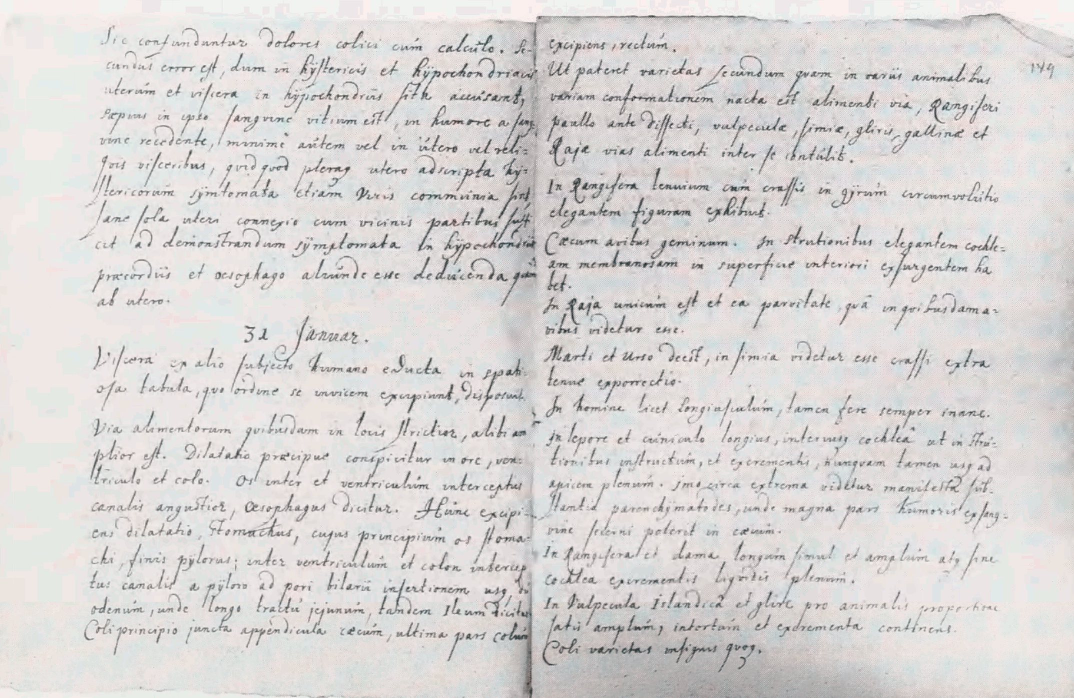
Circa peritonæum et pleuram notandum, varia nomina ut mesenterium, mesaræum, ligamentum suspensorium hepatis, alas vespertilionum uteri, duplicaturas et processus, omnia designare ejusdem membranæ varias partes, prout variè a partibus contentis extenduntur, sic in pectore mediastinum pleuræ pars est.

In pectore Thymum ostendit.

Pericardium cum suo corde, et aqua.

Cordis apex in homine, fere semper aliquantulum sinistrorsum inclinat, basis autem in medio sita ad latera auriculas exhibet.

Pluribus partibus simul concurrentibus, uni earum adscribitur quod alteri debetur. e. vitia fluidorum solidis sæpius attribuuntur. cum in eadem vicinia reperiantur, lien, intestinum exiens ab angustiis mesenterii, ventriculus, Colon et ren, lieni utplurimum sinistri lateres. dolores omnes adscribuntur, licet ipse sæpe integerrimus sit. Sic vidit Stenonius in Fenis semper pro splenetico habiti cadavere lienem optimè se habentem, renem autem sinistrum arenulis plenum. Celeberr. Sylvius confirmavit se in multis quos pro lienosis habuerant, lienem sanum invenisse intestinum autem illi vicinum fere semper tumidum.



Sic confunduntur dolores colici cum calculo. Secundus error est, dum in hystericis et hypochondriacis uterum et viscera in hypochondriis sita accusant, sæpius in ipso sanguine vitium est, in humore a sanguine recedente, minimè autem vel in utero vel reliquis visceribus, quidquod pleraq utero adscripta hystericorum symptomata etiam viris communia sunt sane sola uteri connexio cum vicinis partibus sufficit ad demonstrandum symptomata in hypochondriis præcordiis et oesophago aliunde esse deducenda quam ab utero.

31 Januar.

Viscera ex alio subjecto humano educta in spatiosa tabula, quo ordine se invicem excipiunt, disposuit.

Via alimentorum quibusdam in locis strictior, alibi amplior est. Dilatatio præcipue conspicitur in ore, ventriculo et colo. Os inter et ventriculum interceptus canalis angustior, oesophagus dicitur. Hinc excipiens dilatatio, stomachus, cujus principium os stomachi, finis pylorus; inter ventriculum et colon interceptus canalis a pyloro ad pori bilarii insertionem usq duodenum, unde longo tractu jejunum, tandem Ileum dicitur Coli principio juncta appendicula cæcum, ultima pars colum

excipiens, rectum. 149

Ut pateret varietas secundum quam in variis animalibus variam conformationem nacta est alimenti via, Rangiferi paullo ante dissecti, vulpeculæ, simiæ, gliris, gallinæ et Rajæ vias alimenti inter se contulit.

In Rangifera tenuium cum crassis in gyrum circumvolutio elegantem figuram exhibuit.

Cæcum avibus geminum. In Struthionibus elegantem cochleam membranosam in superficie interiori exsurgentem habet.

In Raja unicum est et ea parvitate, quâ in quibusdam avibus videtur esse.

Marti et Urso deest, in simia videtur esse crassi extra tenue exporrectio.

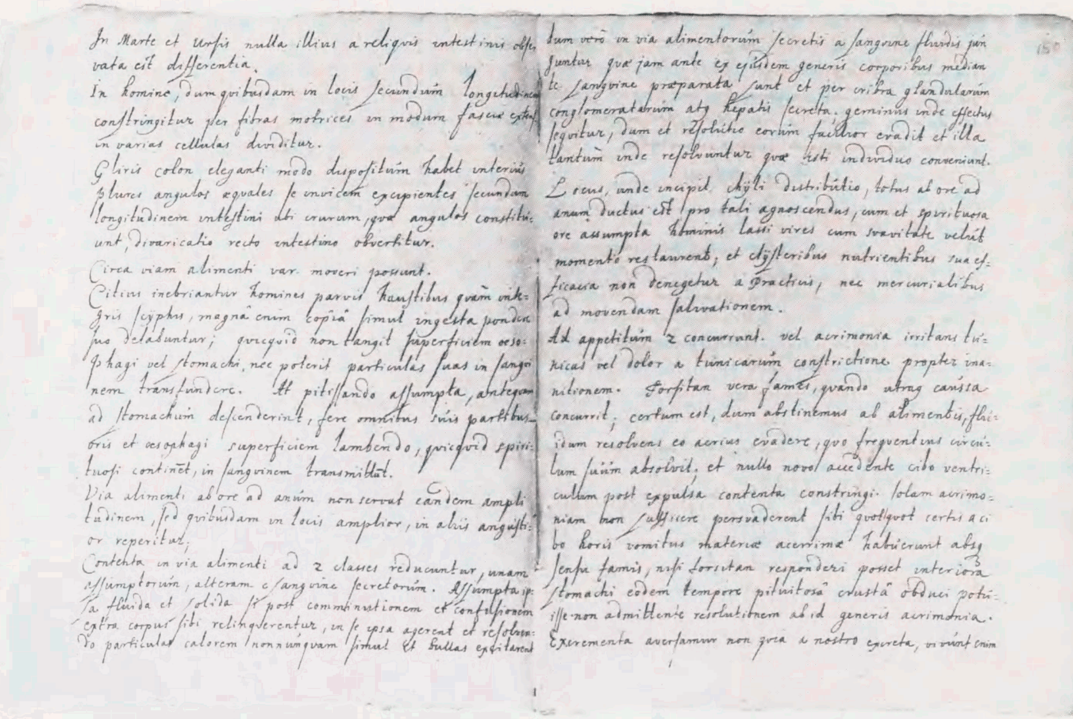
In homine licet longiusculum, tamen fere semper inane.

In lepore et cuniculo longius, internis cochleâ ut in Struthionibus instructum, et excrementis nunquam tamen usq ad apicem plenum. imo circa extrema videtur manifesta substantia parenchymatodes, unde magna pars humoris ex sanguine secerni poterit in cæcum.

In Rangifera et dama longum simul et amplum atq sine cochlea excrementis liquidis plenum.

In Vulpecula Islandica et glire pro animalis proportione satis amplum, intortum et excrementa continens.

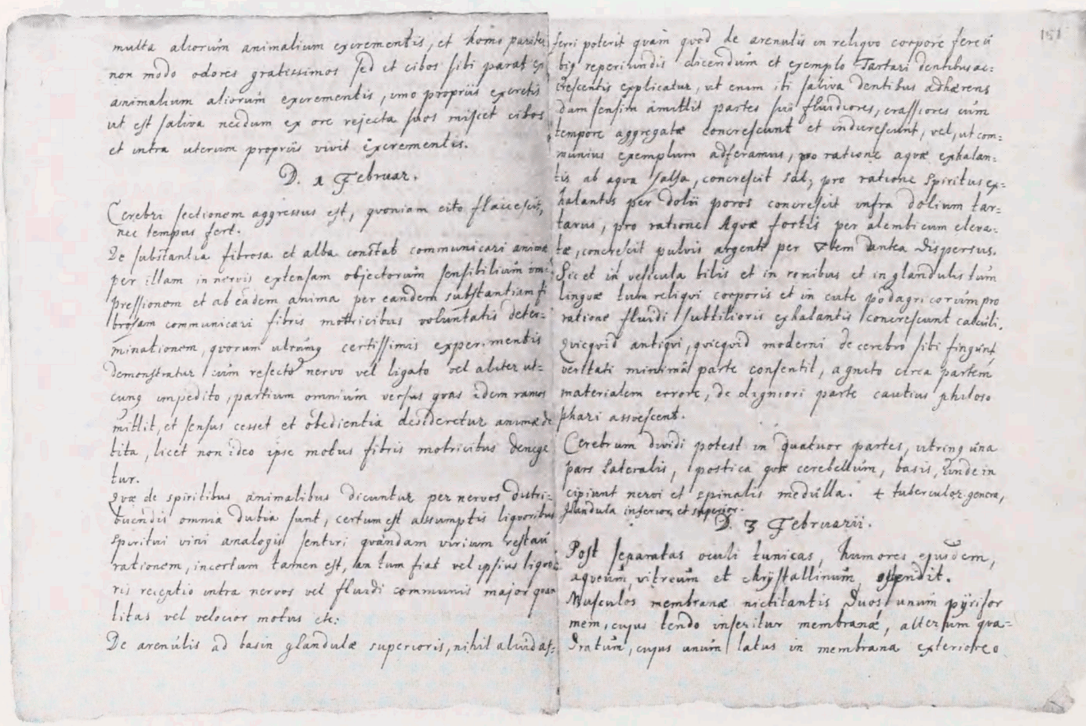
Coli varietas insignis quoq.



In Marte et Ursis nulla illius a reliquis intestini obser
vata est differentia.
In homine, dum quibusdam in locis secundum longitudinem
constringitur per fibras motrices in modum fasciæ extens
in varias cellulas dividitur.
Gliris colon eleganti modo dispositum habet interius
plures angulos æquales se invicem excipientes secundum
longitudinem intestini ubi crurum, quæ angulos constitu=
unt, divaricatio recto intestino obvertitur.
Circa viam alimenti var. moveri possunt.
Citius inebriantur homines parvis haustibus quam inte=
gris scyphis, magna enim copia simul ingesta pondere
suo delabuntur; quicquid non tangit superficiem oeso=
phagi vel stomachi, nec poterit particulas suas in sangui
nem transfundere. At pitissando assumpta, antequam
ad stomachum descenderint, fere omnibus suis partibus
oris et oesophagi superficiem lambendo, quicquid spiri=
tuosi continet, in sanguinem transmittat.
Via alimenti ab ore ad anum non servat eandem ampli
tudinem, sed quibusdam in locis amplior, in aliis angusti=
or reperitur.
Contenta in via alimenti ad 2 classes reducuntur, unam
assumptorum, alteram e sanguine secretorum. Assumpta ip=
sa fluida et solida si post comminutionem et confusionem
extra corpus sibi relinquerentur, in se ipsa agerent et resolven=
do particulas calorem nonnunquam simul et bullas excitarent

dum vero in via alimentorum secretis a sanguine fluidis jun
guntur quæ jam ante ex ejusdem generis corporibus median
te sanguine præparata sunt et per cribra glandularum
conglomeratarum atq hepatis secreta. geminus inde effectus
sequitur, dum et resolutio eorum facilior evadit et illa
tantum inde resolvuntur quæ isti individuo conveniunt.
Locus, unde incipit chyli distributio, totus ab ore ad
anum ductus est pro tali agnoscendus, cum et spirituosa
ore assumpta hominis lassi vires cum suavitate velut
momento restaurent, et clysteribus nutrientibus sua ef=
ficacia non denegetur a practicis, nec mercurialibus
ad movendam salivationem.
Ad appetitum 2 concurrunt. vel acrimonia irritans tu=
nicas vel dolor a tunicarum constrictione propter ina=
nitionem. Forsitan vera fames, quando utraq causa
concurrit; certum est, dum abstinemus ab alimentis, flu=
idum resolvens eo acrius evadere, quo frequentius circu=
lum suum absolvit, et nullo novo accedente cibo ventri=
culum post expulsa contenta constringi. Solam acrimo=
niam non sufficere persuaderent sibi quotquot certis a ci
bo horis vomitus materiæ acerrimæ habuerunt absq
sensu famis, nisi forsitan responderi posset interiora
stomachi eodem tempore pituitosa crusta obduci poti=
usse non admittente resolutionem ab id generis acrimonia.
Excrementa aversamur non quia a nostro excreta, vivunt enim

150



multa aliorum animalium excrementis, et homo pariter
non modo odores gratissimos sed et cibos sibi parat ex
animalium aliorum excrementis, imo propriis excretis
ut est saliva needum ex ore rejecta suos miscet cibos
et intra uterum propriis vivit excrementis.

D. 2 Februar.

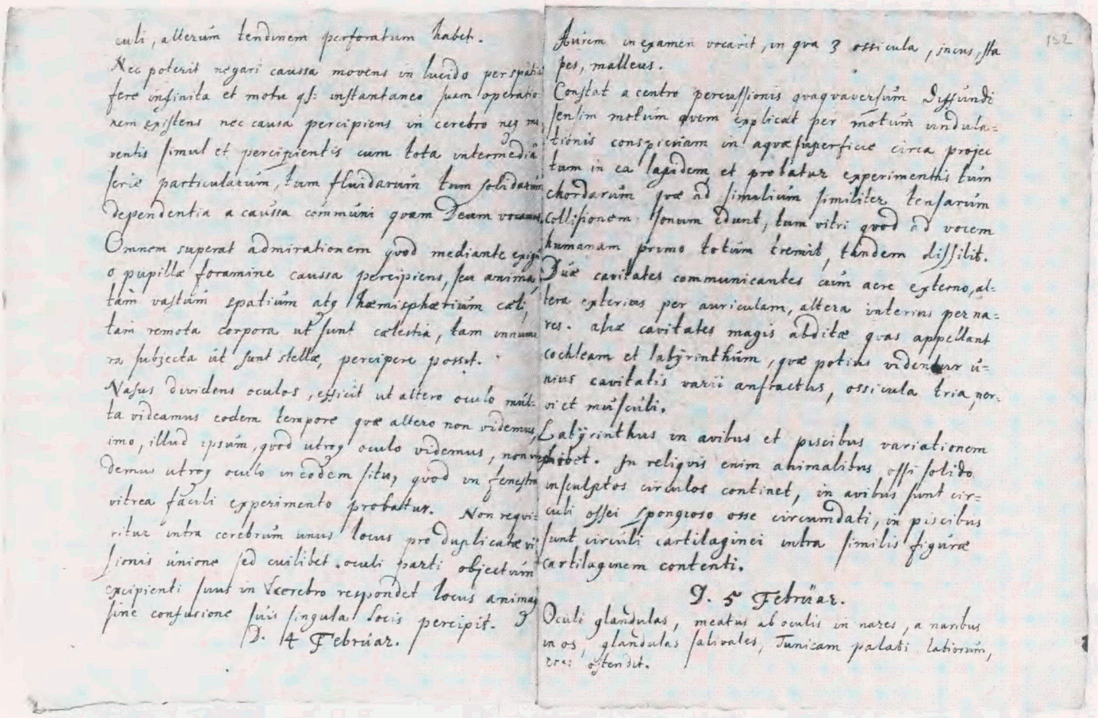
Cerebri sectionem aggressus est, quoniam cito flaccescit,
nec tempus fert.
De substantia fibrosa et alba constat communicari animæ
per illam in nervis extensam objectorum sensibilium im=
pressionem et ab eadem anima per eandem substantiam fi
brosam communicari fibris motricibus voluntatis deter=
minationem, quorum utrumq certissimis experimentis
demonstratur cum resecto nervo vel ligato vel aliter ut=
cunq impedito, partium omnium versus quas idem ramos
mittit, et sensus cesset et obedientia desideretur animæ de
bita, licet non ideo ipse motus fibris motricibus denege
tur.
Quæ de spiritibus animalibus dicuntur per nervos distri=
buendis omnia dubia sunt, certum est assumptis liquoribus
spiritui vini analogis sentiri quandam virium restau
rationem, incertum tamen est, an tum fiat vel ipsius liquo=
ris receptio intra nervos vel fluidi communis major quan
titas vel velocior motus etc.
De arenulis ad basin glandulæ superioris, nihil aliud af=

ferri poterit quam quod de arenulis in reliquo corpore fere u
biq reperiundis dicendum et exemplo Tartari dentibus ac=
crescentis explicatur, ut enim ibi saliva dentibus adhærens
dum sensim amittit partes suas fluidiores, crassiores cum
tempore aggregatæ concrescunt et indurescunt, vel, ut com=
munius exemplum adferamus, pro ratione aquæ exhalan=
tis ab aqua salsa, concrescit sal, pro ratione spiritus ex=
halantis per dolii poros concrescit infra dolium tar=
tarus, pro ratione Aquæ fortis per alembicum eleva=
tæ, concrescit pulvis argenti per ∇tem antea dispersus.
Sic et in vesicula bilis et in renibus et in glandulis tum
linguæ tum reliqui corporis et in cute podagricorum pro
ratione fluidi subtilioris exhalantis concrescunt calculi.
quicquid antiqui, quicquid moderni de cerebro sibi fingunt
veritati minima parte consentit, agnito circa partem
materialem errore, de digniori parte cautius philoso
phari assuescent.
Cerebrum dividi potest in quatuor partes, utrinq una
pars lateralis, postica quæ cerebellum, basis, unde in
cipiunt nervi et spinalis medulla. 4 tubercula, glandula inferior et superior.

D. 3 Februarii.

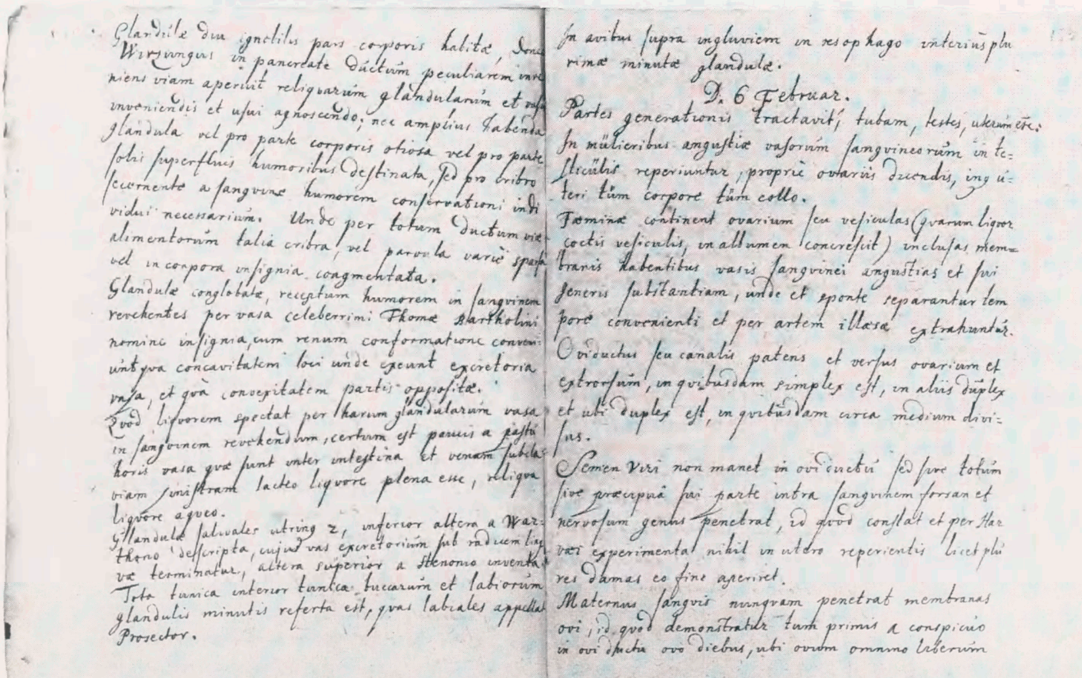
Post separatas oculi tunicas, humores ejusdem,
aqueum, vitreum et chrystallinum, ostendit.
Musculos membranæ nictitantis duos unum pyrifor
mem, cujus tendo inseritur membranæ, alterum qua=
dratum, cujus unum latus in membrana exteriore

151



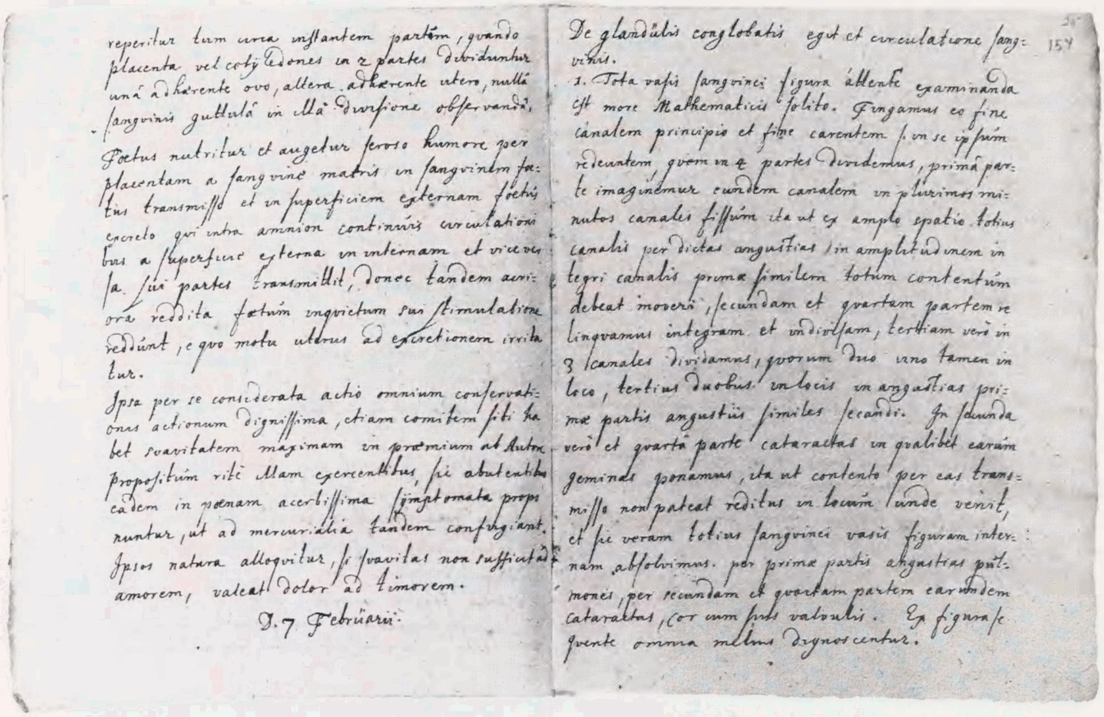
culi, alterum tendinem perforatum habet.
Nec poterit negari caussa movens in lucido per spatia fere infinita et motu qs: instantaneo suam operationem existens nec causa percipiens in cerebro neq movientis simul et percipientis cum tota intermedia serie particularum, tum fluidarum tum solidarum dependentia a caussa communi quam Deum vocant.
Omnem superat admirationem quod mediante exiguo pupillæ foramine caussa percipiens, seu anima, tam vastum spatium atq hæmisphærium cœli, tam remota corpora ut sunt cœlestia, tam innumera subjecta ut sunt stellæ, percipere possit.
Nasus dividens oculos, efficit ut altero oculo multa videamus eodem tempore quæ altero non videmus, imo, illud ipsum, quod utroq oculo videmus, non videmus utroq oculo in eodem situ, quod in fenestra vitrea facili experimento probatur. Non requiritur intra cerebrum unus locus pro duplicatæ visionis unione sed cuilibet oculi parti objectum excipienti sunt in cerebro respondet locus anima sine confusione suis singula locis percipit.
D. 4 Februar.

Aurem in examen vocavit, in qua 3 ossicula, incus, stapes, malleus.
Constat a centro percussionis quaqua versum diffundi sentim motum quem explicat per motum undulationis conspiciam in aquæ superficie circa projectum in ea lapidem et probatur experimentis tum chordarum quæ ad similium similiter tensarum collisionem sonum edunt, tum vitri quod ad vocem humanam primo totum tremit, tandem dissilit.
Duæ cavitates communicantes cum aere externo, altera exterius per auriculam, altera interius per nares. aliæ cavitates magis abditæ quas appellant cochleam et labyrinthum, quæ potius videntur unius cavitatis varii anfractus, ossicula tria, norvi et musculi.
Labyrinthus in avibus et piscibus variationem habet. In reliquis enim animalibus ossi solido insculptos circulos continet, in avibus sunt circuli ossei spongioso osse circumdati, in piscibus sunt circuli cartilaginei intra similis figuræ cartilaginem contenti.
D. 5 Februar.
Oculi glandulas, meatus ab oculis in nares, a naribus in os, glandulas salivales, Tunicam palati labiorum, etc: ostendit.



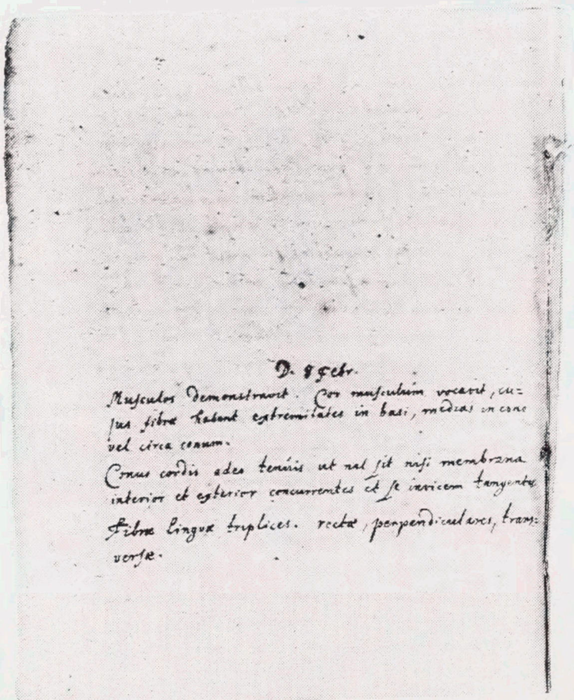
Glandulæ diu ignobilis pars corporis habitæ, dono Wirsungus in pancreate ductum peculiarem inveniens viam aperuit reliquarum glandularum et vasis inveniendis et usui agnoscendo; nec amplius habenda glandula vel pro parte corporis otiosa vel pro parte soli superfluis humoribus destinata, sed pro cribro secernente a sanguine humorem conservationi individui necessarium. Unde per totum ductum viæ alimentorum talia cribra, vel parvula varie sparsa vel in corpora insignia coagmentata.
Glandulæ conglobatæ, receptum humorem in sanguinem revehentes per vasa celeberrimi Thomæ Bartholini nomine insignia, cum renum conformatione conveniunt qua concavitatem loci unde exeunt excretoria vasa, et qua convexitatem partis oppositæ.
Quod liquorem spectat per harum glandularum vasa in sanguinem revehendum, certum est pauuis a pastu horis vasa quæ sunt inter intestina et venam subclaviam sinistram lacteo liquore plena esse, reliqua liquore aqueo.
Glandulæ salivales utrinq 2, inferior altera a Wharthono descripta, cujus vas excretorium sub radicem linguæ terminatur, altera superior a Stenonio inventa.
Tota tunica interior tunicæ buccarum et labiorum glandulis minutis referta est, quas labiales appellat Prosector.

In avibus supra ingluviem in œsophago interius plurimæ minutæ glandulæ.
D. 6 Februar.
Partes generationis tractavit, tubam, testes, uterum etc:
In mulieribus angustiæ vasorum sanguineorum in testiculis reperiuntur, proprie ovariis dicendis, inq uteri tum corpore tum collo.
Fœminæ continent ovarium seu vesiculas (quarum liquor coctis vesiculis, in album en concrescit) inclusas membranis habentibus vasis sanguinei angustias et sui generis substantiam, unde et sponte separantur tempore convenienti et per artem illæsa extrahuntur.
Oviductus seu canalis patens et versus ovarium et extrorsum, in quibusdam simplex est, in aliis duplex et ubi duplex est, in quibusdam circa medium divisus.
Semen viri non manet in oviductu sed sive totum sive præcipua sui parte intra sanguinem forsan et nervosum genus penetrat, id quod constat et per Harvei experimenta nihil in utero reperientis licet plures damas eo fine aperiret.
Maternus sanguis nunquam penetrat membranas ovi, id quod demonstratur tum primis a conspicuo in ovi ductu ovo diebus, ubi ovum omnino liberum



reperitur tum circa instantem partum, quando
placenta vel cotyledones in 2 partes dividuntur
una adhaerente ovo, altera adhaerente utero, nulla
sanguinis guttula in illa divisione observanda.
Foetus nutritur et augetur seroso humore per
placentam a sanguine matris in sanguinem foe:
tus transmisso et in superficiem externam foetus
excreto qui intra amnion continuis circulationi
bus a superficie externa in internam et viceversa
sui partes transmittit, donec tandem aeri:
ora reddita foetum inquietum sui stimulatione
reddunt, e quo motu uterus ad excretionem irrita
tur.
Ipsa per se considerata actio omnium conservati:
onis actionum dignissima, etiam comitem sibi ha
bet suavitatem maximam in praemium ab Autore
propositum rite illam exercentibus, sic abutentibus
eadem in poenam acerbissima symptomata propo
nuntur, ut ad mercurialia tandem confugiant.
Ipsos natura alloquitur, si suavitas non sufficiat ad
amorem, valeat dolor ad timorem.
D. 7 Februarii.

De glandulis conglobatis egit et circulatione sang:
vinis. 154
1. Tota vasis sanguinei figura attente examinanda
est more Mathematicis solito. Fingamus eo fine
canalem principio et fine carentem s. in se ipsum
redeuntem, quem in 4 partes dividemus, prima par:
te imaginemur eundem canalem in plurimos mi:
nutos canales fissum ita ut ex amplo spatio totius
canalis per dictas angustias in amplitudinem in
tegri canalis primae similem totum contentum
debeat moveri, secundam et quartam partem re
linquamus integram et indivisam, tertiam vero in
3 canales dividamus, quorum duo uno tamen in
loco, tertius duobus in locis in angustias pri:
mae partis angustiis similes secandi. In secunda
vero et quarta parte cataractas in qualibet earum
geminas ponamus, ita ut contento per eas trans:
misso non pateat reditus in locum unde venit,
et sic veram totius sanguinei vasis figuram inter:
nam absolvimus. per primae partis angustias pul:
mones, per secundam et quartam partem earundem
cataractas, cor cum suis valvulis. Ex figura se
quente omnia melius dignoscentur.



D. 8 Febr.
Musculos demonstravit. Cor musculum vocavit, cu:
jus fibrae habent extremitates in basi, medias in cono
vel circa conum.
Conus cordis adeo tenuis ut nil sit nisi membrana
interior et exterior concurrentes et se invicem tangentes
Fibrae linguae triplices. rectae, perpendiculares, trans:
versae.

9. Addendum

Introduction

The following is a translation by Sr Emmanuel Collins and Dr Paul Maquet of a Latin manuscript*, written by Niels Stensen, ending up on the cover of a letter with an inscription to him in a different handwriting [90v].

Niels Stensen lived in Hamburg from 1683 to 1685 in a house owned by the ambassador of Florence, Theodor Kerckring.

The main text appears to be the outline for an essay on physiological psychology with (1) physiological evidence on the integrated sensorimotor function of the nervous system used in philosophical arguments for the immateriality of the soul based on the cartesian identification of matter and extension: "that intermediate of mine cannot be extensional", [89r] ... "reflex actions cannot be extensional movements but are actions without movement of parts of something which is extensional [90r]. These arguments are mostly taken from perceptions and reactions common to humans and irrational animals. Connected to this are (2) some other philosophical considerations on natural theology and ethics.

An earlier unobserved figure with legend [90v, part] was noticed in the manuscript by August Ziggelaar who kindly translated this text. To give this illustration a natural place in the rendering, minor relocations were made as indicated from the pagination of the manuscript.

* * *

It is certain that movement and sensation are carried out in animals partly through fibres of the nerves. One of their extremities continues inwards toward the white matter of the brain and of the spinal cord. The other leads outward toward the different organs. <88r>

It is certain that the nervous fibres through which the impulse of perceptible objects is transmitted inwards are different from the nervous fibres through which the decisions of moving are transmitted to the muscles from within.

---

* Biblioteca Nazionale Centrale, Florence, archive number: Galilei 291, fol. The first page of the volume is designated: Posteriori di Galileo; tomo 32; Accademia del Cimento, parte III; Carteggio, vol. 17: Scritti di Niccolò Stenone. The text on fol. 88-90 r-v has been edited by Gustav Scherz as Additamentum 24 in Epistolæ, II, pp 949-51. German translation, see: Schlichting, 1953-54, and Biography, II, p 238.

It is certain that many impulses of perceptible objects are perceived with no subsequent change from inside in the decisions of moving, and that many changes in the decisions occur without any previous change in the impulses from external perceptible objects.

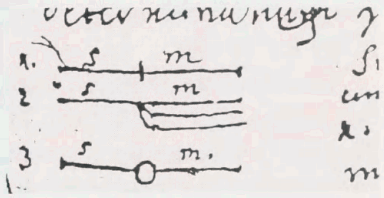
It is certain that very different changes in decisions from inside respond to the same impulses from outside.

It is certain that the same decisions from inside very often respond to different impulses from outside.

The sensory nervous fibres, moreover, can be either immediately connected with the motor nervous fibres in composing the white matter of the brain, whether they are connected one to one or one to several others; or the sensory nervous fibres can have mediate interchange with motor nervous fibres and that, either by way of an extensional substance, whether fluid or solid, or at the same time fluid and solid, which may have diverse forms, or by way of an extensionless substance.

Were sensory nervous fibres interiorly connected with motor nervous fibres, either immediately or by way of a solid of any shape, then similar impulses from outside would always result in similar decisions of moving from inside.

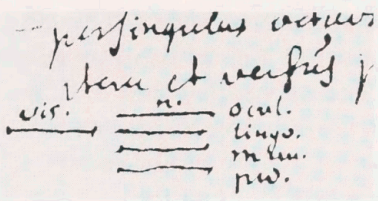
Let the sensory nerve *s* be connected with the motor nerve *m* in figures 1 and 2 (Fig. 18): the impulse through the nerve s necessarily acts in the same manner in the nerve or nerves m as long as they immediately cohere.



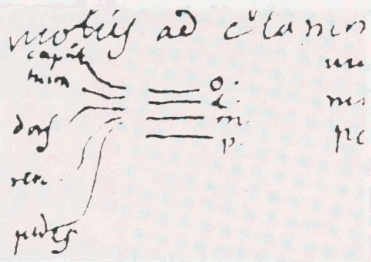
<88v> If some solid body were intermediate, or if it were pervious through pores so that an impulse in any sensory nerve were freely propagated to all motor nerves, and [sic] then it would be about the same as if a fluid were intermediate, and in that instance either the directly opposite filaments alone, or all at once, would always receive the decision responding to the impulse of any sensory fibre.

Actually, when the impulse of the same visible object is transmitted through these same nerves to the mind inside, I am able to determine the movement through the nerves to the muscles of the eyes, in order to fix the eyes on the contemplation of the object; through the nerves of the tongue, in order to explain what I see in the object; through the nerves of the hand, in order to describe or depict the object, even to remove it.

By transmitting inwards an impulse of its own through the nerves of the eyes the same musical note produces infinite changes of decisions from inside, through the nerves to the tongue, whenever it can sing an

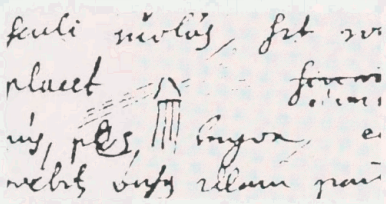


octave above or below it, through the nerves to the individual fingers with which it can strike the same note through single octaves, and also to the feet. (Fig. 19).



When somebody is burned in different places, from the vertex down to the extreme tip of the toes, the call always goes out to the same muscles of speech, the movement is bound to issue a loud cry, the eyes to see what has been done and its source, the hands to remove the pain and the feet to run away. (Fig. 20).

Therefore, there must be an intermediate between the sensory and motor nerves such that at an impulse which is transmitted through a single fibre several fibres in very different places receive a variety of decisions to move, and that in response to an impulse of several very different fibres the same fibres accept a decision to move.



<89r, upper>

That intermediate of mine between the sensory and the motor nerves, perceiving and deciding movement, cannot be extensional, otherwise each nerve would have its own corresponding point and an impulse of the same nerves would always result in the motion of the same corresponding muscle, be this intermediate round or square or triangular, as it pleases. (Fig. 21). When a muscle is burned, or a hand wounded, a foot, the tongue, the same hand will be moved toward that part in such a movement but if it was extensional, pain of the foot would result in movement of another part than of the eye towards the pain,[? so that which arouses a cry moved by 10 different motor nerves would, if otherwise moved by the same 10 nerves, evoke a voice of joy?].

<90v, part> Let there be nerves for external touch.
Let any one of them be rubbed.
The nerves | of the voice
of the eyes
of the hands
of the feet
will be moved.

So from each of these nerves of touch a connection would be necessary[?] to all other nerves of motion. [Fig. 22].

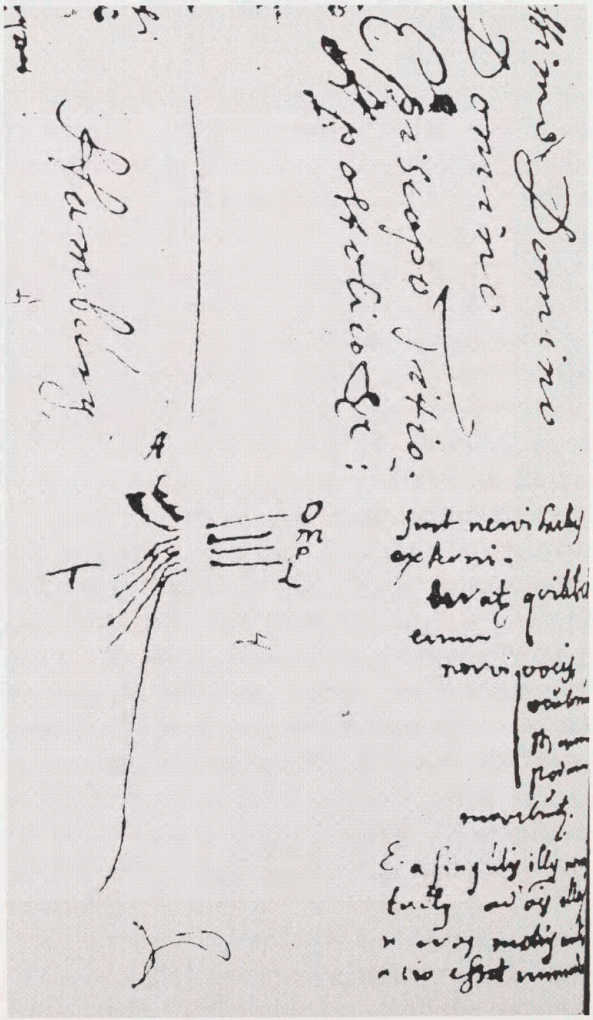


Fig. 22

Since that same [part] of myself perceives the objects of the individual senses, even through many different nerves, and determines the impulses of different movements, even through an indefinite number of nerve fibres, and – also – through reflex action distinguishes between perceptions, perceptions and decisions of moving, and between the very acts of perceptions and decisions of moving and the ... [illegible] <90r>

It is certain that however that [part] of mine may be in extension, those reflex actions cannot be extensional movements but are actions without movement of parts of something which is extensional.

Because the same [part] of mine can examine both the extensions of movement and thoughts of the perceiving [mind] and compare them with the rule of reason, of law, of example [...]

That I must search into[?] the rule of the will [...]

[?Whether speculative truths [are] from death in the mind in what way] <89r, lower>

It is not allowed in all things to argue from speculative to practical truths.

The order fitting individual actions according to dependence of persons on paternal rule, to the property of acquired things while one must provide for the needs of several years.

No study of virtues in Spinoza but study of truths alone.

I can acknowledge through natural light alone that <89v>

life is addicted to sensual pleasures and pains,

life is conform to pre-judgments from images of fantasy about honours and wealth,

life is conform to the laws of natural reason,

life depends on the immediate rule of him whom I acknowledge as the creator of all things, always seeing the minds of all humans, regulating all by permitting or ordering. When thus I acknowledge him as the ruler of the world and wiser and mightier than myself, then I can realize the imperfection of my rule, coming from myself, its perfection, if taken over by the supreme Deity.

To pray, naturally is to acknowledge that one cannot do that, to acknowledge that a superior cause can do it, and to desire that a supreme cause takes it on itself.

To the Illustrious and most Reverend Lord and most honourable Protector, Lord Niels Stensen, Bishop of Titiopolis, Apostolic Vicar, etc. <90v, part>

To be delivered at [the address of] the Ambassador of the Grand Duke of Florence, H. Kerckring. Hamburg.

10. Dansk resume

Mine tidligere udgivelser om Niels Stensen rummer kommenterede engelske oversættelser af nogle mindre kendte videnskabelige værker, *Steno on Hydrocephalus*, 1993, *Steno on Muscles*, 1994, og en mindre kendt 1700-tals engelsk oversættelse af et kendt Stensen-værk, *A specimen of observations upon the muscles*, 1986, hvortil kommer kommenterende artikler i fagtidsskrifter på dansk og engelsk. Under arbejdet hermed blev det klart, at der her foreligger fundamentale observationer og fortolkninger, som i vid udstrækning er blevet overset. For muskelteoriens vedkommende drejer det sig om grundlæggende biologiske principper, som forfatteren selv satte højt, men som blev forkastet af fagvidenskaben og negligeret i Stensen-litteraturen. For hydrocephalusarbejdets vedkommende drejer det sig om et overset pionerarbejde inden for hjernens fysiologi, embryologi og patoanatomi. Som anført i these II i *Steno on muscles* skønnede jeg, at der var et behov for en nyvurdering af Stensens samlede videnskabelige arbejder og metode, hvilket er sigtet med denne afhandling.

I kapitel 1 har jeg gennemgået Stensens videnskabelige værker med relation til hans livsforløb og i lyset af samtidens og eftertidens vurderinger. Sidstnævnte er opsummeret i en tabel i kapitel 5. Hidtil upåagtet er Stensens beskrivelse af kompartmenteringen af den levende organismes væskerum (afsnit 3.3), en omfattende og detaljeret teoridannelse inden for et område, hvor dansk forskning siden har høstet megen anerkendelse. Stensens tekst står i *De solido intra solidum*, som i 1902 blev oversat til dansk af August Krogh og Vilhelm Maar,[1] men tilsyneladende uden at den er kommet til at indgå som reference i dansk kapillær- og væskefysiologi. Stensens teori fremstår som en ramme uden bevisførelse for udveksling af kropsvæskerne mellem forskellige adskilte væskerum.

Niels Stensen er en af de danske videnskabsmænd, hvis arbejder påkaldte sig størst opmærksomhed i samtiden. Alligevel viser det sig, at også hans teorier inden for andre videnskabsdiscipliner – palæontologi, geologi og krystallografi – først sent vandt indpas i de respektive videnskaber gennem genopdagelse. En analyse af værkerne viser en korrekthed og detaljerigdom, som gør det vanskeligt at opretholde det synspunkt, at Niels Stensen i sin rastløshed efterlod sine teorier

1. Steno, 1902, pp 25 ff.

uafsluttede. Sammenholdes værkerne *Discours sur l'anatomie du cerveau*, Paris 1664/69, og *Elementorum myologiæ specimen*, Firenze 1667, kan en indholdsmæssig sammenhæng erkendes. I førstnævnte værk beskrives det cerebrale og i sidstnævnte værk det muskulære aspekt af den levende organismes motoriske funktion.

To bevarede manuskripter, *Chaos*-manuskriptet og det her i bogen oversatte *Addendum* fra Hamburg-perioden, viser en ubrudt evne og interesse for videnskaben lige fra studietiden til kort før Niels Stensens død. Det kan dermed afvises, at Stensens religiøse udvikling indtrådte på et tidspunkt, da han ikke længere evnede videnskaben. Min vurdering er, at Stensens primære motivation for videnskaben var delvis religiøs, som det fremgår af sidste led i det indledende citat (p 7). De videnskabelige skrifter fremkom succesivt som respons på krav, som han var stillet overfor: Kirtelafhandlingerne fra Leiden-perioden som graduat-arbejder; hjerneforelæsningen i Paris og muskel- og geologiske arbejder i Firenze, kalvedissektionen i Innsbruck og indledningsforelæsningen i København som ydelser i forhold til én privat og tre fyrstelige sponsorer. Fra 1674 stilledes der ham ikke længere videnskabelige opgaver, og han koncentrerer sig om sin religiøse hovedinteresse, men, som det fremgår af *Addendum* og prædikenen *Ornamenta* omtalt i afsnit 1.13, uden at tabe interessen for videnskaben.

Kapitel 2 gennemgår kort eftertidens interesse for personen Niels Stensen og hans skrifter, som foreligger i monumentale udgivelser redigeret af Vilhelm Maar, Gustav Scherz og Knud Larsen. En bærende del af litteraturen om Stensen er dansk – eksempler herpå er at finde på bagomslaget af denne bog! Den religiøse interesse kulminerede med saligkåringen i den katolske kirke i 1986.

I kapitel 3 giver jeg en fremstilling af Niels Stensens videnskabelige metode og litteraturen herom. Jeg viser, at fra den første til den sidste linie i det videnskabelige forfatterskab foreligger der videnskabsfilosofiske betragtninger, og at hovedværket herom er indledningsforelæsningen *Prooemium*, som her for første gang gengives på engelsk. Holger Jacobæus' beskrivelse af Stensens efterfølgende dissektion af et kvindelig bringes for første gang i oversættelse. Den er en bred gennemgang af den menneskelige organismes anatomi og fysiologi, som havde egnet sig godt som lærebog i biologi.

Nøglen til min egen forskning er Vilhelm Maars bemærkning i introduktionen til *Nicolai Stenonis Opera Philosophica* 1910, om at Stensen stillede sine spørgsmål og gav sine svar som en videnskabsmand i vort århundrede. Men hvilken metode er det da? Skønt ikke formuleret på Vilhelm Maars tid peger udsagn og fremgangsmåde hos Stensen på den af Karl R. Popper beskrevne metode, hvis nøgleord er »Conjectures and refutations«, hvilket vil sige at man gætter sine prob-

lemløsninger, som herefter udsættes for energiske forsøg på forkastelse.

I min gennemgang af Stensens metode afgrænser jeg følgende komponenter. I afsnit 3.1 en strukturel del, hvori Stensen foretager en sammenligning mellem en observeret struktur og en forestilling eller mental model baseret på litteraturen eller en myte. Enhver afvigelse foranledigede en mistanke eller et gæt, om at forestillingen var forkert. Dette igangsatte hans forskningsaktivitet, ved at undersøgelsen blev gentaget under samme eller under ændrede vilkår, samt ved at den litterære kilde blev gransket pånyt. Stensens opdagelser kan på denne måde deles i hidtil ubeskrevne strukturer, såsom ørespytkirtelens udførselsgang, og korrektioner af fejlopfattelser, såsom Descartes' forestilling om en roterende koglekirtel i hjernen til styring af menneskets bevægelser gennem fordeling af spiritus animalis til forskellige muskler i kroppen. Stephen J. Gould har beskrevet et videnskabskriterium hos Stensen som »tilstrækkelig lighed«. Bag enhver lighed ligger en sammenligningsproces – hvilket indgår i indledningscitatet, p 7 – hvorved forestillingen karakteriseres som sand eller falsk. Jeg konkluderer, at Stensen opfylder videnskabskriteriet tilstrækkelig lighed ved at foretage multiple sammenligninger.

I afsnit 3.2 omtales Stensens praktiske snilde. Adskillige kilder beskriver hans usædvanlige evner som anatom og skarpe syn.

I afsnit 3.3 omtales hans behandling af observationer i tidsforløb som dynamiske modeller omfattende muskelkontraktionen, krystallers vækst og jordlagenes alder med klar afstandtagen fra fiktive principper som årsagsforklaring. For de geologiske teoriers vedkommende drejer det sig om fortolkning af begivenheder foregået i en tid, som ligger udenfor direkte observationers kontrol. Sådanne teorier formuleredes som *conjecturae*, dvs gæt, som Stensen selv forsøgte og inviterede læseren til at være med til at modbevise. Da der kun forelå indirekte evidens, karakteriserede han sine synspunkter som værende ikke langt fra sandheden. Muskelkontraktionen er beskrevet ved en geometrisk analyse, hvortil han formulerede en programerklæring, afsnit 3.4.

Den ovenfor omtalte væsketeori er formuleret med det formål at vise, at stendannelse i organismen i form af galdesten, nyresten, spytsten mm. finder sted i et såkaldt eksternt væskerum. Den korrekte ramme for opdeling af legemsvæskerne i den levende organisme har vist ingen taget notits af.

Stensens skrifter er præget af en sproglig rigdom, som den danske oversætter af indledningsforelæsningen A. Kragelund fandt, at ingen oversættelse blot tilnærmelsesvis kan gengive, et synspunkt som gruppen omkring nærværende oversættelser deler. I afsnit 3.5 fremdrages flere eksempler på den omhu gennem detaljeret ordforklaring, som

Stensen udviste. I det ved trykningen benyttede manuskript til *Elementorum myologiæ specimen*, som er bevaret i Det kgl. Bibliotek, ses forfatterens omhu med den skriftlige formulering gennem op mod hundrede store og små egenhændige rettelser.

Sigtet for Stensen med den videnskabelige undersøgelse er som anført i afsnit 3.6 at tilnærme sig en skjult sandhed i naturen og dermed dens skabende årsag gennem en demonstrativ sikkerhed. En bevidst holdning som realist indebærer for Stensen en bevidst holdning til, at erkendelse opnås ved at afdække dele af en grænseløs uvidenhed, karakteriseret som rummende langt den største skønhed. Denne den virkelige verden – *res, ut sunt* (p 120) – adskilte han i indledningsforelæsningen fra fornuftens begreb om tingene, som svarer til menneskenes begrænsede vilkår. Erfaringen viste ham, at overleveret erkendelse var fuld af fejl. Han var bevidst om, at fejltagelser opstod også hos ham selv gennem sansernes fejlbarlighed samt ved utilstrækkeligt eller fejlagtigt grundlag for de dragne konklusioner. Han advarede mod forudindtagethed og mod konklusioner ud fra enkeltobservationer og mod analogislutninger. Stensen er konsekvent antiautoritær – påtrufne synspunkter blev afprøvet. Eksempelvis (afsnit 1.3) kom det til at gå ud over hans professor Thomas Bartholins højt udbasunerede teori, om at hjertet er sædet for blodets dannelse, gennem Stensens kendte these: hjertet er alene en muskel, formuleret mens han som 26-årig stod uden stilling i København. Hans mod og selvstændighed gik ikke tabt ved konverteringen: få år senere anvendte han karakteristikken »den store Galilei« i en afhandling udgivet med censurens billigelse i Italien (afsnit 3.6).

11. Index of Names

Source references in the footnotes are in italics

ACTA HISTORICA SCIENTIARUM NATURALIUM ET MEDICINALIUM

Published by The Danish National Library of Science and Medicine

9. O. Neugebauer. The exact sciences in Antiquity. 2nd ed. 1957. 240 pp. 110.- DKK.
12. E. J. Dijksterhuis: Archimedes. 1956. 422 pp. 150.- DKK.
13. Olaf Pedersen: Nicole Oresme og hans naturfilosofiske system. En undersøgelse af hans skrift »Le livre du ciel et du monde«. 1956. 290 pp. 100.- DKK.
14. Gustav Scherz: Vom Wege Niels Steensens. Beiträge zu seiner naturwissenschaftlichen Entwicklung. 1956. 248 pp. 180.- DKK.
16. Heinz Goerke: Die deutsch-schwedischen Beziehungen in der Medizin des achtzehnten Jahrhunderts. 1958. 185 pp. 115.- DKK.
18. Gustav Scherz: Pionier der Wissenschaft. Niels Steensen in seinen Schriften. 1963. 348 pp. 200.- DKK.
19. Bernt Løppenthin: Danske ynglefugle i fortid og nutid. 1967. 609 pp. 200.- DKK.
20. Gustav Scherz (ed.): Steno. Geological papers. Translation by Axel J. Pollock. 1969. 370 pp. 200.- DKK.
21. Die ornitologische Korrespondenz zwischen Johann Friedrich Naumann und Heinrich Rudolf Schinz in den Jahren 1815-1835, von Erwin Stresemann und Ludwig Baege. 1969. 88 pp. 45.- DKK.
22. Franz Djørup: Bidrag til anatomiens historie i Danmark. 1970. 118 pp. 60.- DKK.
23. Gustav Scherz (ed.): Dissertations on Steno as geologist. 1971. 319 pp. 200.- DKK.
24. C. Barker Jørgensen: John Huntr, A. A. Berthold, and the origins of endocrinology. 1971. 54 pp. 45.- DKK.
25. Taisbak, Christian Marinus: Division and logos. A theory of equivalent couples and sets of integers. Proponded by Euclid in The Arithmetical Books of the Elements. 1971. 129 pp. 65.- DKK.
26. August Ziggelaar: Le physicien Ignace Gaston Pardies, S. J. (1636-1673). 1971. 242 pp. 120.- DKK.
27. J. Genner: The Medical Society of Copenhagen 1772-1972. 345 pp. 125.- DKK.
28. Thorkild Schiøler: Roman and Islamic water-lifting wheels. 201 pp. 115.- DKK.
29. E. Snorrason: C. G. Kratzenstein, professor physices experimentalis Petropol. et Havn. and his studies on electricity during the eighteenth century. 1974. 206 pp. 125.- DKK.
30. Olaf Pedersen: A survey of the Almagest. 1974. 454 pp. 200.- DKK.
31. Harald Nielsen: Ancient ophthalmological agents. A pharmaco-historical study of the collyria and seals for collyria used during Roman Antiquity, as well as of the most frequent components of the collyria. 1974. 117 pp. 75.- DKK.
32.. Petrus Severinus og hans Idea medicinæ philosophicæ. En dansk paracelsist. Idea medicinæ er oversat af Hans Skov. Indledning og kommentarer ved E. Bastholm. 1979. 299 pp. 150.- DKK.
33. Dyre Trolle: The history of Caesarean section. 1982. 109 pp. 100.- DKK.
34. Georg Mohr: Compendium Euclidis Curiosi: Dat is Meetkonstig Passer-Werck etc. Amsterdam 1673 & Compendium Euclidis Curiosi: or geometrical operations. Transl. by Joseph Moxon. London 1677. 1982. 68 pp. 60.- DKK.
35. Paul Rønne and Arnold B. W. Nielsen: Development of the ion X-ray tube. 1986. 271 pp. 410.- DKK.
36. Dansk zoologisk bibliografi/Danish zoological bibliography 1907-1945. *Alphabetical index.* Compiled by Poul Borella and Sigrid Borella. 1986. 419 pp. 160.- DKK.
37. Dansk zoologisk bibliografi/Danish zoological bibliography 1907-1945. *Systematic indexes.* Compiled by Poul Borella and Sigrid Borella. 1986. 475 pp. 160.- DKK.
38. Niels Stensen. A Danish student in his Chaos-manuscript 1659. 1986. 131 pp. 150.- DKK.
39. J. L. Berggren & B. R. Goldstein (eds.): From ancient omens to statistical mechanics: Essays on the exact sciences presented to Asger Aaboe. 1987. 298 pp. 285.- DKK.
40. Erasmus Bartholin: Experiments on birefringent Icelandic crystal. Translated by Thomas Archibald. With an introduction by Jed Z. Buchwald and Kurt Møller Pedersen. With a facsimile of the Latin original. 1991. 126 pp. 160.- DKK.
41. Thomas Bartholin: On diseases in the Bible. A medical miscellany. 1672. Translated from the Latin by James Willis. Edited with an introduction by Johan Schioldann-Nielsen and Kurt Sørensen. 1993. 148 pp. 200.- DKK.
42. Troels Kardel: STENO · Life · Science · Philosophy. 1994. 160 pp. 200.- DKK.

Volumes not listed above are out of print.